THE GROWTH AND PREVENTION

OF

ELECTRICAL ENERGY DIVERSION

A THESIS

SUBMITTED TO THE DEPARTMENT OF ELECTRICAL ENGINEERING

AND THE GRADUATE COUNCIL OF THE GEORGIA SCHOOL OF

TECHNOLOGY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

FOR THE DEGREE OF

MASTER OF SCIENCE

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FOREWORD

In this thesis, an attempt is made to provide people interested in the subject of "Energy Diversion" with a reasonably complete record of the growth and prevention of this widespread practice. References to practically all articles published in English will be of help to those who wish to pursue the subject further. To my knowledge, this thesis is the first of its kind, as information on this subject is very hard to obtain, and what little published information exists is very scattered, in most cases dealing with special phases of the problem. Much of the information to be presented was secured by me in talks with public utility men who work in this field but who would not be quoted. Consequently, in putting this information in this thesis, no authority can be given other than mine.

In the fall of 1932, when casually looking at a copy of the "Electrical World," I found an article on the subject of "electrical energy diversion," a term used by the public utilities for the crude sounding phrase, "theft of electrical power."

This problem was new to me. I had never before realized to what serious proportions the evil had grown. Its solution is vital to the very existence of public utilities, because unless remedied, the revenues upon which everything depends are greatly reduced.

Some time later, a different approach to the problem occurred to me. It consisted of some suitable relay scheme to automatically interrupt service to customers who attempted to divert electrical energy from their meters so that they would be compelled to call the power company to get the service restored. Thus the utility would be protected against theft, and the customer would have service as long as he used it legitimately. The problem was discussed with Mr. H. L. Newman, and it was decided to attempt to develop together a suitable relay scheme that would accomplish the desired results. Mr. C. L. Lambert, a mutual friend, agreed to finance the work in return for a share of any income that might be derived from it.

The ensuing investigation and experimental work was made principally in the electrical laboratories and work shops of Georgia Tech. Professor Fitzgerald, Head of the Electrical Engineering Department, and Professor Duling, Head of the Electrical Laboratory, made the investigation possible by extending the greatest cooperation in the use of the laboratory and its equipment. We greatly appreciated the courtesy.

I wish to express my sincere thanks to Mr. Henderson, Head of the Atlanta Division Operating Department of the Georgia Power Company, for his interest, help, and suggestions, which were of the greatest assistance in actually trying out the device on suspected customers in his division.

Mr. Patrick, Head of the Meter Department of the Atlanta Division, and Mr. Wiggins, Chief Investigator of Energy Diversion in the Atlanta Division, both of the Georgia Power Company, have my thanks for their cooperation in installing the theft relays and maintaining records of their operation.

H. T. Yopp

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THE GROWTH AND PREVENTION OF ELECTRICAL ENERGY DIVERSION

Electrical energy diversion is defined as the use of electric power by or through unauthorized and fraudulent methods. The methods used can be classified into two divisions: (1) those where unauthorized electric power never flows through the watt-hour meter and (2) those where various methods are used to prevent the proper recording of the correct amount of power used.

The subject of energy diversion is a difficult one about which to write. Because of its very nature, little information is known and still less is published in books or magazines. Therefore, the writer was forced to go to considerable trouble in securing some of the material presented here, as it was necessary to make appointments with the suitable officials of several utilities located from Maryland to Florida to get first hand information. Also, a great many engineering salesmen whom the writer knows, traveling for companies that sell equipment to reduce energy diversion, were very helpful. Because of their wide traveling, they have a good knowledge of the estimated extent of the practice of energy diversion and of the problems involved in combating it.

The electric utilities as a whole paid little attention to energy diversion until about 1918, when C. M. Ward of the Duquesne Light Company of Pittsburgh published an article, "Protection Against Thieving Customers," in the November 30, 1918, "Electrical World." In a three month test of 3884 meters, it was concluded that about 5% of their customers were guilty of energy diversion. This finding was a surprise to many utility executives who believed the practice to be negligible.

However, in spite of this report and others similar to it, the problem* was ignored for years. This was due principally to the enormous expansion of the electric utilities. All of their effort and time went towards extending power lines, building power plants, and improving service. Revenues were increasing in proportion; so the money lost because of energy diversion was many times made up by the addition of new customers.

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* Preventing Theft of Electric Service -- Ralph Pittman, Electrical World, August 18, 1923.

INCREASE OF ENERGY DIVERSION

Energy diversion as a serious problem first began to be considered in 1931. By then, revenues were falling and new customers were very few; so means of increasing the income of the utilities were sought. It was found that the practice of energy diversion had increased greatly and was very widespread in some localities such as Florida, Mississippi, Louisiana, Georgia, and other states scattered all over the country, and in most all the large cities.

This increase of energy diversion has several causes, principal among them being:

1. The enormous growth of the electric distribution systems.
2. The growth of knowledge of elementary electricity, partly due to the great increase of electrical repair shops and garages.
3. More and more students were enrolled in high schools that taught elementary electricity in physics courses, thus spreading further electrical knowledge.
4. The incentive to steal power increased as the use of electricity per person increased. Electric bills in some businesses are an appreciable item of the total expenses of the business.
5. The big, recent increase was due to the economic depression. Many people who would not consider such an action ordinarily, resorted to energy diversion.

6. Because of the depression, great numbers of trained utility employees, together with expert house-wiring and electrical repair men, were thrown out of work. Many of them make a business of selling their knowledge to reduce light bills by various unauthorized means.

In 1931, a number of utilities made surveys of their territory only to be amazed at their findings. Mr. S. A. Fletcher,** writing in the Electrical World of November 21, 1931, about these surveys, said, "Although many utility managers have long believed they were free from loss of revenue by energy diversion, one utility recently found evidence of 1500 cases of theft in a town with a total of 9000 customers. This means that one out of every six customers gets some part of his electrical energy without paying for it. Another utility has recently begun an active campaign for detection of current theft and has found as many as 56 suspects in one day." These are, of course, extreme cases, but they give an idea as to the extent of energy diversion in some localities.

By 1931, energy diversion was recognized as being practiced all over the United States. It was, and still is, even worse in Mexico, Cuba, Central and South America, where utilities have had, and are having, a fight for their very exis-

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** Also see article by M. M. Koch, "System Losses - Their Analysis and Reduction" -- Electrical World, November 28, 1931.

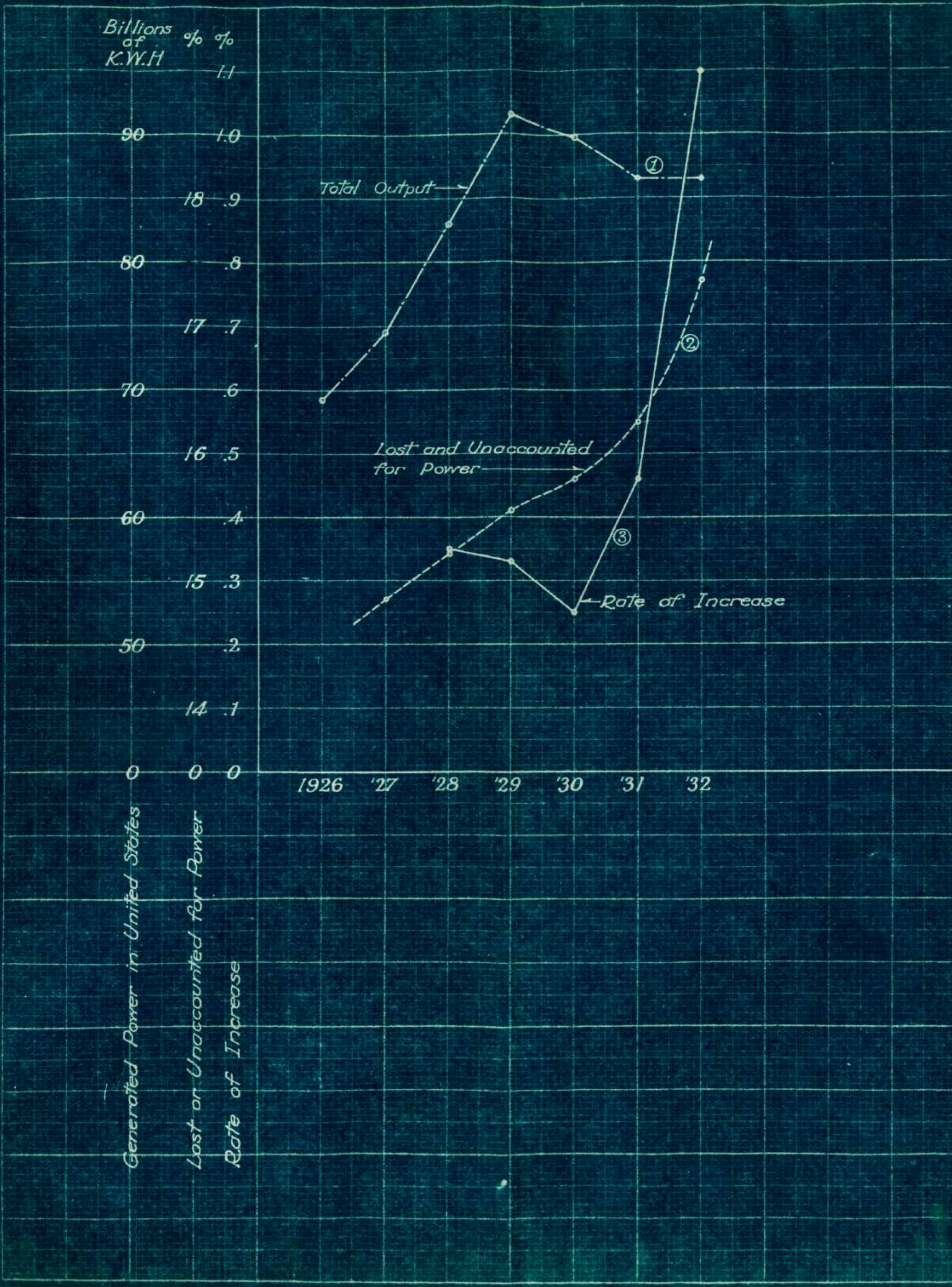
tence on account of this evil. In the United States, energy diversion is more widespread in the larger cities where great numbers of old houses and duplex apartments with old wiring exist. Usually the wires are open and are easily accessible, coming inside the house for a ways before reaching the electric meter. In duplex apartments, the problem is especially bad, as it is impossible to cut off the service when one honest customer lives with several dishonest ones. In proportion to customers, the southern states are the worst offenders, the percentage decreasing some for the northern states, although the amount of power stolen in the northern states is greater . However, in Canada, energy diversion gives very little trouble.

Some idea of the increase of energy diversion in the United States may be obtained from the curves shown in the accompanying diagram. Three curves are shown: (1) the total output of electrical energy; (2) the percentage of unaccounted for losses; and (3) an increment curve showing the rate of change of the percentage losses, all plotted for the years from 1927 through 1932.

The power output curve shows a steady increase from 1926 until 1929, when an all-time peak was established, after which a decline set in, which should be especially noted in relation to the other curves.

Curve No. 2 shows the percentage of unaccounted for losses. These losses include transmission and distribution losses which may be called legitimate, and losses due to power theft, which may be classed as illegitimate. It will be noted that the power output since 1929 has decreased, and it would be expected that legitimate losses, which are dependent on load conditions would also decrease. The facts, however, show just the opposite. Curve No. 2 shows a steady increase from 1927 to 1930, which is in keeping with the increasing load during that period. Although the output has decreased since 1930, curve No. 2 shows a sharp increase in unaccounted for losses. The writer believes that a large part of this increase is due to power theft, since it seems reasonable to believe that legitimate losses would decline with declining output.

To bring out more clearly this increase in unaccounted for losses, curve No. 3 shows that the rate of increase of these losses since 1930 has risen sharply. This brings out more forcibly the fact that unaccounted for losses, or rather their rate of increase, is rapidly rising, notwithstanding the decline in output, whereas we would expect these losses to decrease in keeping with the diminishing output.



Billions of K.W.H
% %
1.1
90 1.0
18 .9
80 .8
17 .7
70 .6
16 .5
60 .4
15 .3
50 .2
14 .1
0 0 0
1926 '27 '28 '29 '30 '31 '32
Total Output
Lost and Unaccounted for Power
Rate of Increase
①
②
③
Generated Power in United States
Lost or Unaccounted for Power
Rate of Increase

REVENUE LOSSES

To give some idea of the loss in revenue suffered by the power companies because of energy diversion, the author has made an effort to estimate the loss for each of the major power companies in the United States. In order that the figures may not be thought of as being too high, comparison between the method used in this paper and the results obtained through using estimates of other sources shows that the figures given here are between half and two-thirds of those obtained from other sources.

An editorial in the "Electrical World" of August 6, 1932, entitled, "Energy Diversion and the Necessity for Change in Meter Practice," says, "Some estimates that have been made as to its extent (the practice of energy diversion) have run as high as 5% (of the generated energy) but if this figure reflects too pessimistic an opinion of public honesty, and assuming that the true figure is only 1%, it would still represent an appreciable source of revenue leaks and would still be worth going after."

In talks with power company engineers and engineering salesmen, the author has found that they believe the practice of energy diversion is far more widespread than the very conservative figures set forth in the above editorial. The writer has been told of instances where the amount of power stolen runs as high as fifty per cent, although this is admittedly an extreme case. In the opinion of these men, this practice is increasing rapidly each year.

The Westinghouse Electric and Manufacturing Company, in a publication describing their new socket detachable meter, described elsewhere in this paper, says, "It is doubtful if any utility can show a loss of energy from this same source as low as 1% (of total generated power). Some utilities where this loss was thought to be negligible, have discovered it to be as high as 10% (of generated power). In some cases 18% of domestic customers were practicing this "art" in various ways."

An excellent article giving some idea of the revenue losses from energy diversion is to be found in the "Electric Journal" of October, 1934. The article is by W. W. Palmer and is titled, "Rumors Pay Dividends."

To return to the method used to approximate the revenue losses of the major private utilities of this country, column 18 of Table II of the chart on the second page from this, shows the "not accounted for losses" of the individual companies listed in that table. These include all legitimate losses such as those due to transmission and distribution, and illegitimate losses due to power theft. No attempt is made in the table to separate these losses, but a very reasonable estimate (the writer believes) can be made of the percentage of those losses due to power theft. Seven per cent of the unaccounted for losses is taken as being due to power theft. This leaves ninety-three per cent of the unaccounted for losses due to legitimate sources. As an example, the estimated loss for the Florida Power and Light Company will be calculated. This company is No. 93 on the previously mentioned chart. Column 18 shows for this company an unaccounted for loss of 46,733,057 KWH, this being a loss of 23.6% as shown in the first column. 7% of this is approximately 3,270,000 KWH. At 3¢ per KWH, this represents an annual loss of about $100,000.

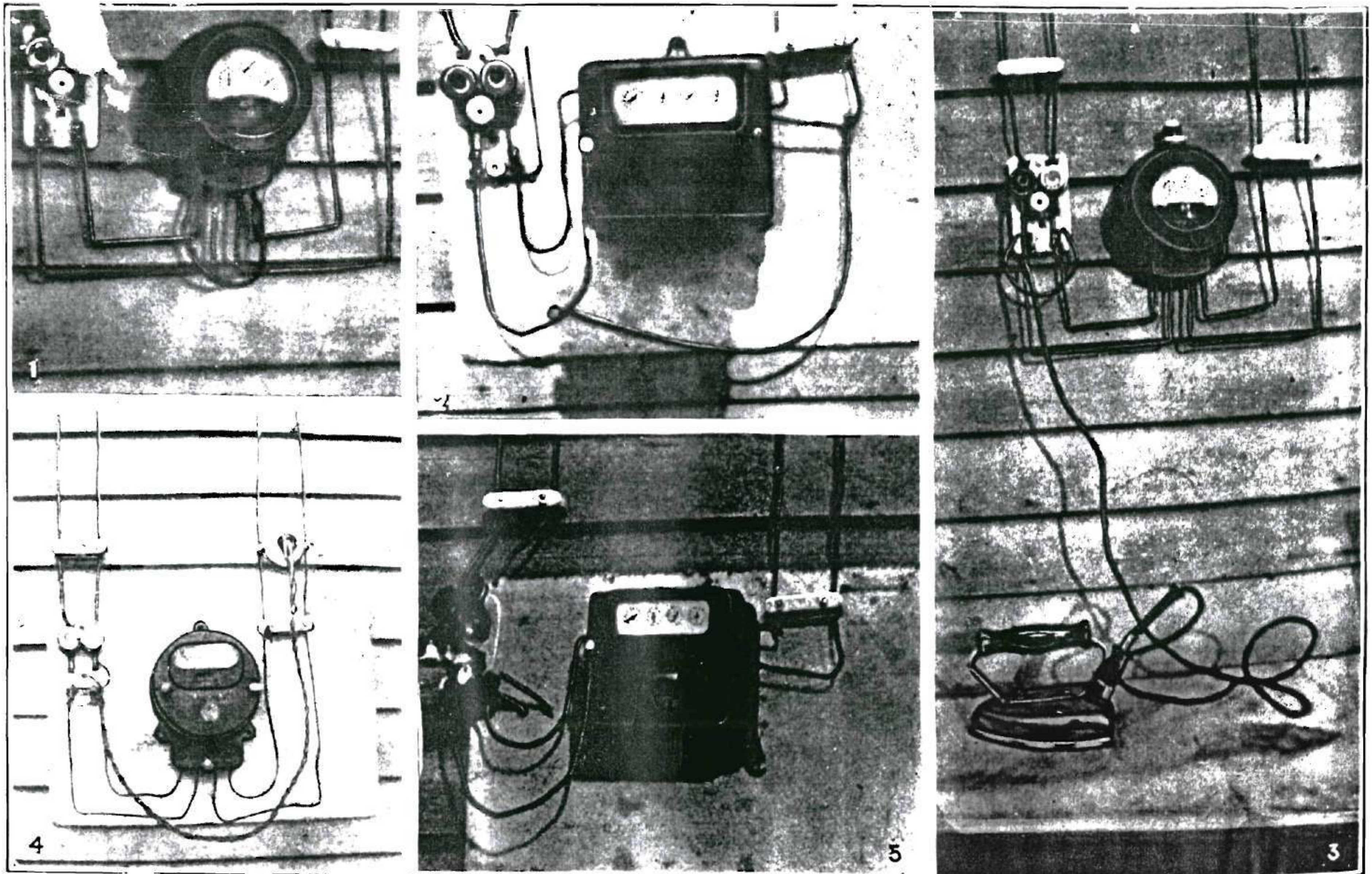
It will be noted that this estimate of power theft is a <u>percentage of admittedly unaccounted for losses</u>. Since power theft must be included in these losses, it is reasonable to assume that it must constitute some percentage of them, and it is believed that an average figure of seven per cent of these losses is a reasonable estimate, perhaps too reasonable.

The writer is aware that his method of calculating the extent of power theft is not at all rigorous. Its sole purpose is to give the reader an approximate idea of the extent of the practice of energy diversion in terms of dollars and cents. It is recognized, of course, that some companies transmit their power further to their load centers than others and that some distribution systems are old and some are new; that some distribution densities, that is, the number of customers per mile of distribution line, are low and some high; and that because of these and other factors, some power companies have a greater legitimate loss than others, but, if some idea of the sums of money involved in this practice of energy diversion is given the reader, the purpose of the estimation of these losses is fulfilled.

METHODS USED IN POWER THEFT

The principal methods used to steal power are:

1. Backing out of the line fuse located ahead of the meter. This gives unmetered service on half of the house.
2. Placing shunt wires on the meter so that most of the current goes through shunt wires.
3. Tapping a load to the line wires ahead of the meter.
4. Reversal of rotation of the meter disc.
5. Boring holes in the meter cover and inserting objects such as hairpins through the hole to make the meter disc run slower or stop altogether.
6. Reversing the ground and power lines to the meter.
7. Altering temporarily the position of the meter, such as letting it hang down or at an angle in order to slow or stop the disc.
8. Causing gases to penetrate the meter cover which make gummy deposits on the meter disc and bearings that slow or stop the disc.



FIGS. 1 TO 5—VARIOUS METHODS OF PUTTING METER WHOLLY OR PARTIALLY OUT OF SERVICE

EFFORTS TO COMBAT ENERGY DIVERSION

One of the first efforts to lessen the losses due to energy diversion was the installation of safety steel fuse cabinets which were sealed. The main line fuse and switch were the most accessible parts of the wiring system and theft occurred at this point more frequently than elsewhere.* These steel switch and fuse cabinets were well worth their cost, but as most of the wiring was open, people found that the insulation could be removed and jumper connections made around the meter, or the lines to the house distribution system could be tapped without much trouble. This practice was, and still is, very hard to detect if cleverly done, because of the greater number of almost inaccessible places a jumper can be attached to the wires ahead of the meter, especially when the service wires enter the house through the attic. Power companies in Mexico and Cuba attacked this part of the problem by installing concentric cable from the pole to the meter. The cable was connected so that the neutral or grounded wire was outside. The use of concentric cable has rapidly increased in the United States, especially in small towns and rural districts where the electrical wiring codes in use in the particular places permitted its use. In places where it could not be used, steps were taken to secure the revision of the local electrical code. In larger cities, conduit was specified for all new wiring from the

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*Electrical World, July 15, 1932.

service entrance to the meter, which gave about as much protection as concentric cable.

There were still two very weak links in the wiring and recording system, namely, the steel fuse boxes and the unprotected meters. People continued to break open sealed fuse boxes and steal power. When asked about the broken seal, a blown fuse was offered as the reason for breaking it to insert a good fuse. Even though the power companies knew that theft was occurring, nothing could be done about it, as a broken seal, under these conditions, was no evidence of theft that would hold in court. A few offenders could be caught in the act of stealing, but the great majority were smart enough to remove jumpers or screw in fuses before a meter reader or investigator was admitted to the meter.

Court action in the cases where offenders were caught almost always resulted in acquittal for the accused. Few juries would convict anybody of stealing from the power companies because of the great loss of good will suffered by the industry due to the depression, and to the general ill feeling against the utilities prevalent in most parts of the country. Also, if the power company failed to secure a conviction, it was faced with a big libel suit by the person accused of theft. These libel suits were very easy to win because of the same factors mentioned above. One Florida utility started an intensive campaign against power theft by making court cases against a number of people against whom a good deal of evidence had been secured. The idea was to make an example of these offenders to discourage other customers from continuing the practice. Day after day the attendance at these trials grew until standing room was hard to find in the courtroom. Such extraordinary interest puzzled the power company and the court. The jury failed to convict a single offender despite eye witnesses to fraud in several cases. A few weeks later a regular epidemic of energy diversion broke out, almost doubling the trouble previously experienced. The company discovered to its sorrow that the spectators at the trials had carefully memorized the methods of stealing explained to the jury as evidence by the power company lawyers and, convinced of their immunity to prosecution, had proceeded to make full use of their new knowledge. Besides this, most of the accused people brought libel suits against the power company that cost considerable money to settle out of court.

Power thieves found that tiny holes could be drilled in the glass bowls on the KWH meters and the rotating disc stopped or retarded by inserting a wire or hairpin through the hole. Also, meters were unfastened at the top and allowed to fall forward so that the rotating disc scraped and stopped. By refastening the meter in its regular position, the disc would start to rotate again.

Methods such as these forced the adoption of indoor meter boxes* with concentric cable or conduit. The National Electric Code was finally changed to permit the placing of

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* Electrical World, September 15, 1934, "Solves Many Metering Problems," Albert J. Allen.

the main line switch and fuses on the load side of the meter. This made it possible to use conduit or concentric cable without a break to the meter.

Some utilities began experimenting with outdoor meter installations** with the meter placed in a weather-proof, metal box with the service encased in conduit from the meter box to the point where the wires first contact the building. This type of installation proved to be very satisfactory; as all the wiring, including the meter, is in full view of the meter reader. Also, if the customer tampered with his wiring or meter, he had to do so outdoors, in full view of anyone looking at the time, although he might do so at night. But even then, the meter reader would notice the wiring when he read the meter.

Outdoor meter installations are now standard for new installations in many parts of the South and West, and their use is steadily increasing everywhere.

The latest improvement in this method of metering electricity is the S type, socket meter, first developed by the Westinghouse Electric and Manufacturing Company, which is illustrated on the next page.

It is an assembly of parts whereby any standard meter, from 1915 to date, may be converted into a more theft-proof device. In brief, the meter mechanism is mounted and wired to a panel which is plugged into a cast iron bowl or recep-

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** Electrical World, July 14, 1934, "20 Years of Outdoor Metering" - O. E. House.

tacle, much as a radio tube is plugged into its socket. Then a glass bowl is put over the meter and locked with a special locking ring and seal. The iron receptable is threaded at top and bottom for conduit, and fits into the conduit at any desired point.

The problem of dealing with energy diversion is somewhat peculiar in that many indirect methods have to be used to combat the practice.

Utilities, at the present, value the good will of their customers very highly and will go to about any length to keep it. At least the more progressive companies have this attitude, and rightly so. It follows, then, that when a customer is suspected of stealing power, extreme care must be used in investigating the case. An inspector must get to the meter at least once, usually more, to inspect it and the electric wiring all the way back to the point where the wires first touch the house. He must accomplish his purpose without making the customer suspicious or angry, if possible, and above all, must not accuse the customer of theft even when a jumper is found in use, or definite evidence found of other means to defraud the power company. A bungling investigator can easily lose the good will of half a dozen innocent customers in catching one guilty one, and this is worse than if the guilty one had remained uncaught.

Power company investigators have considerable difficulty in catching power stealing customers in the act of theft. However, the finding of positive evidence that power has been illegally diverted from the meter is not too hard, since it is very difficult to tap onto wires or switches without leaving cut or broken insulation, scratches on switch blades or contacts, streaks in dust collected on walls, etc.* But it has been found, as previously mentioned, that the best of evidence, even eye witnesses, will not always convict in court. This means a potential libel suit every time a court case is made. This is very unsatisfactory from the utility standpoint. But perhaps the greatest objection to legal action in cases of power theft is that the utility has no assurance that theft of power will not be resorted to again.

Some utilities tried, and some are still using, a policy in dealing with customers suspected of power theft, and those of whose guilt no doubt exists, that is perhaps best described by following the action of such a case.

One of their customers, say a Mr. Brown, is found to have a power bill of approximately half that of a year ago. The bill for each of the twelve months shows a gradual decrease from the preceding month. Discreet inquiry by a special investigator shows that the same number of people are using the premises where the meter is located, that an electric refrigerator and several appliances have been purchased by the customer during the year. An inspection of the customer's meter and wiring shows that both of the hot service lines (a 3 wire, 220 volt service) have been stripped of insulation for about an inch in a remote part of

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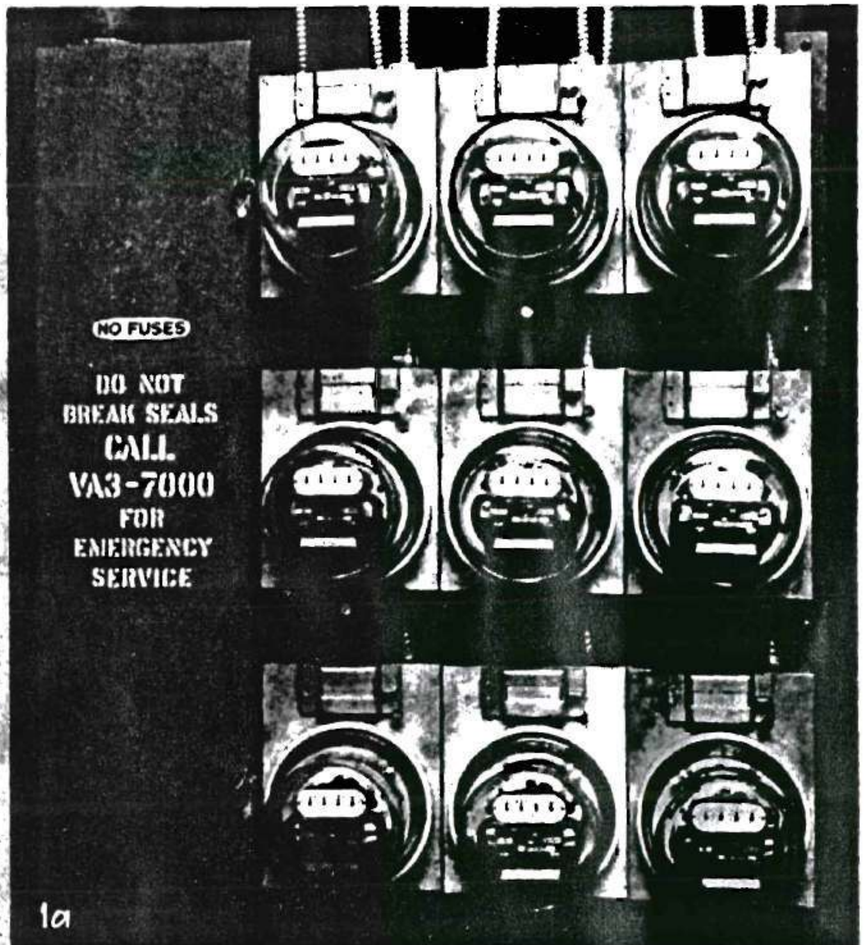
*Electrical Journal, October, 1934 -- "Rumors Pay Dividends", by W. W. Palmer.



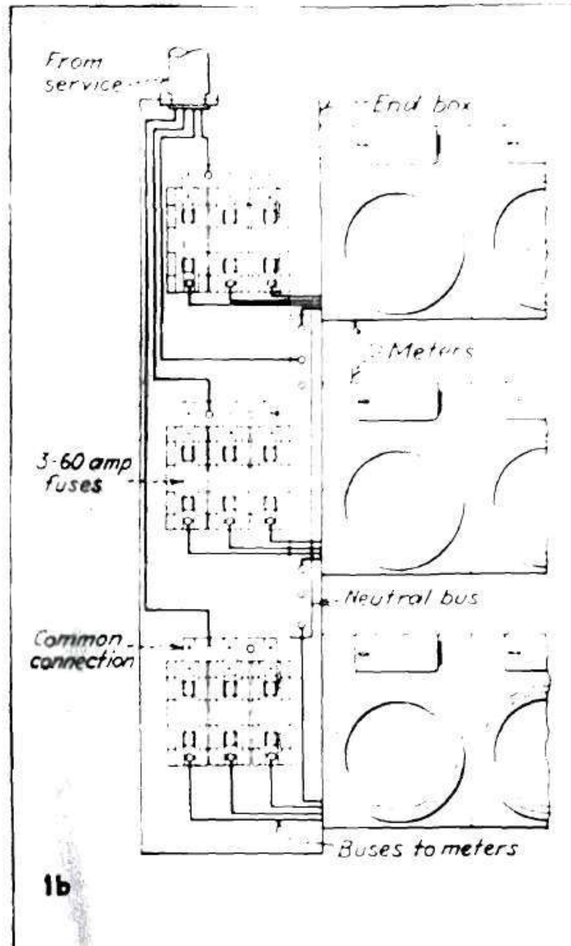


Fig. 1a and b—Ganged meters on new sub-base

For details of mountings see Figs. 2a and b. Meter groups are supplied from three-phase, four - wire sources and meters are distributed on phases except where there are less than eight meters, which are connected to one phase only. The service wires to each row of meters are grouped and run as horizontal buses through lower compartment of the meter mounts. Where fuses are required for meter circuits, they are grouped for each row. As each group is at the same potential there is no hazard of phase-to-phase short circuits.

the attic. Dust marks indicate the presence of a wire or pair of wires at some time in the past. With the above evidence, little doubt can exist but that Mr. Brown is guilty of energy diversion. Yet, it would not be desirable to go to court about the matter, both from a publicity viewpoint and from the almost certainty that the above evidence would not secure a conviction.

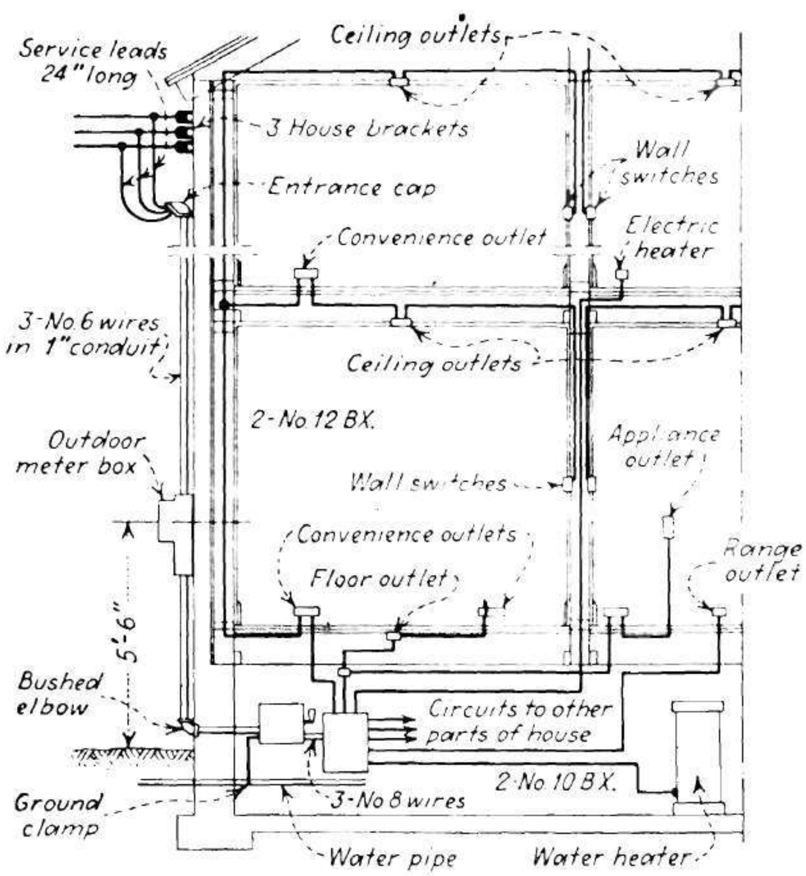
Mr. Brown is sent a registered letter, a delivery receipt being required, stating that his wiring is in a hazardous condition and for him to tell his contractor to get in touch with the power company to find out what must be done to correct the situation. If Mr. Brown follows the instructions in the letter, everything is well, as the utility specifies the most modern type of theft proof installation to be put in at Mr. Brown's expense. If, though, Mr. Brown himself appears at the power company's offices demanding to know the reason for such a letter, he is shown every courtesy while the evidence is told to him, leaving the impression that only a little part of what is really known about him is being discussed and intimating that the company is ready to go to court with the case. The company representative is very careful never to say that Mr. Brown is stealing power. It is claimed that a talk on the above lines produces results most of the time.

Mr. Brown may be a "tough" customer and say that the power company under its charter must provide service for all, that the service cannot be legally cut off as long as he paid his bill unless it could be proven in court that he

Outdoor Meters Installed According to Southern Standards

Meter installation regulations of Southern Public Utilities Company require that, as far as practicable, outdoor meter boxes are to be installed on all new wiring of single-phase services. It also applies to some rearranged wiring or addition to existing circuits where the capacity does not exceed 60 amp. if switch and fuses are used; when circuit breakers are used the limiting capacity is 70 amp.

The outdoor box is located about 5½ ft. from the ground. A 60-amp. entrance switch is placed inside close to the entrance and the grounding is made to available water pipe at this point. The surface branch circuit cabinet may be installed elsewhere if more feasible. Three No. 6 wires are prescribed as a minimum as far as the switch and three No. 8 wires thence to the branch cabinet.



Outdoor meter in box; grounding inside to water pipe

was a thief, that the burden of proof was on the company, and that he would sue for libel if he was acquitted. In a case like this, the utility has no recourse but to install the best protective outdoor meter at its own expense. Such a course of action as outlined above might be termed a "bluff" policy and is employed very successfully by a great many power companies.*

Most of the utilities, at the present, employ a number of specially trained investigators to make inspections and report on suspicious cases and to run to earth any clues and tips, for which rewards are offered, that are telephoned or told to power company employees.

At least one company** considers that the time of its investigators is too valuable to make several trips attempting to catch a thieving customer; so if sufficient evidence cannot be secured in one or two trips to the customer's premises, the power company proceeds to install an outdoor meter at its own expense.

It is generally conceded that a modern socket type outdoor meter mounted clear of all shrubbery with all of the service wires enclosed in conduit from the point where the wires first touch the house, and with all the conduit visible for instant inspection by the meter reader, comprises the most theft proof metering system known at present. This

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* Current Theft and its Prevention -- J. S. Fletcher, Electrical World, November 21, 1931.

** Electrical World, October, 1934 -- W. W. Palmer, "Rumors Pay Dividends."

type of metering system is comparatively new and operating experience is lacking. Yet, it seems to the writer that one very strong defect remains, which may, in time to come, completely reverse the trend towards outdoor meters.

The complete accessibility of the meter at all times, cited as a deterrent to power theft because the customer must tamper with the meter outdoors in full view of anyone watching at the time, may become a boomerang and cause the removal of meters indoors again. If the meter is accessible to everyone at all times of the day or night, the customer cannot be held responsible for the condition of the meter at any time. That is, if the meter reader finds the seals broken on the meter and the meter disc stopped, what could be done about it if the customer denied all knowledge of the deed? Suppose he laid the blame on some personal enemies or some of the neighborhood children, and said that he was not responsible for anything outside his home that was open to all people? The customer, in all probability guilty, could, and can, tamper with the seals of outdoor meters if he does it at night to avoid being seen, and can probably get away with it easily, at least so it appears to the writer. Happily, this trouble has not been encountered so far as the author knows. Yet it will come up sooner or later, and it is well to consider as many aspects of the outdoor metering system as possible so that contingencies like this may be avoided. The author believes that this same outdoor metering system installed indoors would give more protection than if installed outdoors. The above argument cannot be used by a customer when the meter seals are found broken. It is true that the dangers of the lines ahead of the meter being tapped are increased, but if suitably enclosed in conduit or if concentric cable is used, this danger is decreased to some extent.

There will always be some thieving customers who know quite a lot about electricity and who also are very ingenious. No metering equipment so far devised will keep them from making and executing plans, such as to reverse the direction of the meter disc rotation, bore through the conduit and tap the lines ahead of the meter, install long, concealed shunt wires around the meter (boring through brick wall if necessary), tapping the lines by boring through the walls back of the meter, etc.

The writer, in collaboration with Mr. H. L. Newman, has devised an electric relay system which it is believed provides the best answer to problems of this kind. This system is designed to be used when ordinary means fail to protect the revenue of the power company. The detailed presentation of this relay system forms the second portion of this thesis.

END OF PART I.

PREFACE
to
PART II

The foregoing remarks cover in a general way the history, growth, and prevention, of energy diversion up to the present time. The new types of outdoor installations are all that are required in many cases, but there will be customers that are not stopped by conduit or concentric cable. Mr. H. L. Newman and I have developed a new method of combating energy diversion designed to cope with those customers who are not stopped by any of the ways and means already described.

We collaborated in developing the variations shown in figures 1, 2 and 3. Figure 4 is my variation alone. Figure 5 is an invention of mine, and I believe that the tamper proof meter cover described in this paper is a considerable improvement over those used at present.

The purpose of this device is to prevent energy diversion by automatically interrupting service at the pole whenever fraud is attempted, service being restored only by an authorized person. It offers the greatest protection of any method now being used.

The device consists essentially of two units, one being placed on the pole or some other inaccessible point, and the other in the meter box. For the usual two wire 110 volt installation, one extra wire is required between the pole unit and the meter box. The device consumes practically no energy, causes practically no voltage drop, and can be installed to conform with modern code requirements. The device is unaffected by abnormal load conditions on the load side of the meter, such as short circuits or grounds.

Authorities who have been consulted say that this device is practical from both engineering and economic standpoints. A preliminary analysis shows that the cost of it installed compares favorably with a concentric cable, outdoor meter installation being little, if any, higher.

This device offers the following outstanding advantages:

1. The powerful psychological effect produced by interruption of service and the necessity of informing the power company to restore it, strongly discourages further attempts to divert energy.
2. By <u>preventing</u> energy from being stolen, the necessity for catching and prosecuting offenders is eliminated.

In view of these advantages and the reasonable cost of the device, it should have a great appeal to power companies.

PART II

The operation of the system illustrated in Fig. 1 is as follows:*

As previously stated, the system operates on alternating current, and the present description will be based on the assumption that the current is flowing in one direction. In other words, the operation during the flow of one current impulse will be described. The current flows from line wire 12 through wire 17 to the switch arm 18 which is normally held in closed position against the tension of the spring 25 by the thermostatic element 32. Accordingly current will flow through contact 23, wire 24 and fuse 43, and thence through the branch wires 44 and 45 and their respective primary coils 46 and 47. The ampere turns of these coils are equal and opposite whereby they neutralize each other, and accordingly no net flux will be generated in the core of the differential transformer and the magnet 41 will be de-energized. Under such conditions, the armature switch 40 will remain open and no current will flow through the heating coil 33.

The current obviously divides through the coils 46 and 47 and then flows through wires 56 and 57, coils 59 and 60 and wires 61 and 62. These wires are connected to the common wire 63, and current flows through this wire, through

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*From patent #1,987,153 - page 3, col. 2 to page 5, col. 1, line 22, then from line 58 to page 5, col. 2, line 10.

resistance 65, wire 66, meter 67 and wire 68. The flow of current described takes place if a load is connected across the wires 68 and 72, across wires 68 and 73, or across both sets of wires.

After passing through the load, the current returns through wires 72 and/or 73, wire 14 and neutral wire 11. The ampere turns of the coils 59 and 60 are equal and opposite, whereby the coils neutralize each other, and thus no net flux will be set up in the core of the differential choke coils. The drop in potential across the outlet wires due to the use of the small resistance 65 is negligible.

As previously stated, the present system is unaffected by the relationship of the loads connected across the wire 68 and wire 72 and across the wires 68 and 73, but a wholly different result follows if an unscrupulous person attempts to utilize current which is not metered, either by shunting around the meter or by tapping the wires ahead of the meter. As previously stated, the box 58 is located within the building or at any point where the meter ordinarily would be placed, while the box 13 is arranged at an inaccessible point, preferably on the light pole. For connecting the elements within the two boxes, it is desirable in practice that two-conductor concentric cable be employed to render it more difficult to tap the wires, although the operation of the system is not dependent on the use of any particular form of lead wires.

If an unscrupulous person attempts to shunt around the meter, there will be no way in which he can determine which wires to connect, and if either of the wires 56 or 57 is connected to either of the wires 72 or 73, a short circuit obviously will result, thus immediately burning out the fuses. The same result will follow if an attempt is made to connect the wires 14 and 68. If a load is connected across either the wires 14 and 57 or 14 and 56, no fuses will be blown, but the switch will be caused to open.

Assuming that a load is connected across the wires 14 and 57, it will become apparent that the coils 46 and 47 will be immediately unbalanced, thus generating a flow of flux through the core of the differential transformer. Under the conditions referred to, current at a given instant will flow through the primary transformer coil 47, through wire 57, through the load and thence through the neutral wire 14. At the same time, current will flow through transformer coil 46, wire 56, through the coils 59 and 60 in series, through wire 57; through the load and thence through wire 14. As previously stated, the ampere turns of coils 59 and 60 are equal and opposite, and this is true during legitimate use of current at the outlet side of the meter, but under the conditions being considered, the effects of the coils 59 and 60 would be added to each other, whereby both act as choke coils. This double choking effect would occur in the circuit of the primary coil 46, whereas substantially no resistance would exist in the circuit of coil 47, and thus the coils 46 and 47 would be unbalanced.

This condition would cause the flow of a net flux in the core of the transformer to generate a current in the circuit of the secondary coil 48. The relay coil 41 will then become energized to attract its armature 40, thus moving the latter into engagement with the contact 39 to close the circuit through the heating coil 33. This circuit is closed through wire 17, switch 18, wires 24 and 42, through the switch 40, wire 38, coil 33, and wires 16 and 14.

The closing of this circuit obviously heats the coil 33, and the thermostatic element 32 is caused to bend upwardly to release the upper end of the finger 37, whereupon the spring 25 moves the switch 18 to open position. The entire circuit to the building thus will be opened, and since the consumer of the current has no access to the box 13, he cannot restore the circuit, but is forced to notify the power company in order that an operator may be sent out to open the box 13 and close the switch 18. In actual practice, it has been found that the switch 18 will open if an unbalanced load of the character referred to remains in operation for approximately three seconds.

Assuming that the primary coils 46 and 47 are separate coils, their windings obviously will neutralize each other. If such system is employed, it will be apparent that equal loads may be simultaneously connected across the wires 14 and 56 and wires 14 and 57 without unbalancing the coils 46 and 47, in which case the system would not operate. Such loads, however, would have to be simultaneously connected since, as previously stated, the switch 18 opens in approximately three seconds after the balance between the coils 46 and 47 is disturbed. Moreover, the use of almost exactly equal loads across the wires 14 and 56 and 14 and 57 would be required to prevent the opening of the switch 18, and such fraudulent use of current would be highly unpracticable.

The transformer shown in Figure 3 of patent #1,987,153 is such that the system will operate perfectly if equal loads are connected across the points indicated. A single primary coil 52 is employed, and the wire 24 is tapped into the coil 52 intermediate the ends of the latter and at a point spaced from its center. Under such conditions, the two primary coils thus provided will be equal in ampere-turns if loads are connected in the circuit beyond the meter. These primary coils, however, will be promptly unbalanced by having their ampere-turn relationship destroyed if a load is connected, for example, across the wires 14 and 57, thus generating a flux flow to induce current in the secondary coil 48. In view of the fact that the wire 24 is not tapped into the coil 52 centrally thereof, current cannot be fraudulently used by connecting equal loads across the wires 14 and 56 and 14 and 57, and such fraudulent use of current could be obtained only by employing respective loads bearing the same relationship as the turns of the two primary coils into which the coil 52 is divided. The relationship between the primary coils of the transformer shown in Figure 3 of patent #1,987,153 is not subject to any particular limitations, and may be of such character as to make it substantially impossible to employ loads ahead of the meter in the same ratio as the primary transformer coils.

For example, the turns of the primary coils may be in the ratio of 2 to 1, $2\frac{1}{2}$ to 1, 2-7/8 to 1, etc., and if desired, different apparatus may be made with primary transformer coils of different ratios.

Referring again to Figure 1, if an attempt is made to use current fraudulently by shunting around the meter by a wire connected between the wire 68 and either 56 or 57, a disturbance in the normal flow of current will occur to unbalance the coils 46 and 47 and thus cause the relay coil 41 to be energized to break the circuit through the switch 18. For example, if a shunt is connected between the wire 56 and the wire 68, the coil 60 becomes the primary coil of a current transformer upon the connection of a load across the wire 68 and, for example, the wire 72. Under such conditions, current will flow through coil 60, wires 62 and 63, resistance 65, through the wire 66, meter 67, wire 68 and through the load, and thence through wire 72, and wire 14. The coil 60 thus generates a current through the coil 59 and its associated wires and through the shunt connected around the box 58, and if the resistance of such secondary circuit were substantially zero, the secondary current would be substantially equal to the primary current in the circuit of the coil 60. Under such conditions, there would be no net flux in the core 64, and the coils 59 and 60 would remain balanced. In other words, such result would follow if the shunt were connected between the wires 56 and 63, but the latter wire is not available for the reason that it is enclosed within the box 58, and a shunt around the meter box accordingly necessarily includes the resistance 65 if the shunt is connected in the manner previously described, namely, between the wires 56 and 68. The resistance 65 is relatively low, and its effect on the current flowing through the coil 60 is negligible. However, the introduction of the resistance into the circuit of the coil 59 and the shunt connected around the meter box reduces the secondary current generated in such circuit by the primary coil 60.

Of course, the current flowing over wire 56 divides through the shunt wire and the coil 59, but this does not affect the reduction of the net current in the circuit of the coil 59 and the shunt connection, since the greater the normally divided current that flows through the coil 59, the less will be the current through the coil 59 generated by the primary coil 60. The unbalancing of the coils 59 and 60 thus results in the generation of flux in the core 64 whereby the coil 60 is caused to act as a choke to reduce the current in the line including the differential transformer coil 47 and the coil 60. The reduction in the resistance of the circuit including the coil 46 and wire 56 through the use of the shunt connection thus results in the substantial unbalancing of the coils 46 and 47 whereupon flux is generated in the differential transformer core to cause the generation of current in the circuit of the secondary coil 48 and its relay 41. Under such conditions the circuit through the switch 18 will be broken in the manner previously described.

The foregoing result covers the shunting across the wires 56 and 68, and obviously the same result would follow the connection of a shunt wire between the wires 57 and 68. The only difference would be that the coil 59 would become a transformer primary coil to generate current in the circuit including the coil 60 and the shunt connection, whereupon the coil 59 would act as a choke and the coils 46 and 47 would become unbalanced. Obviously a shunt between the wire 14 and either of the wires 72 and 73 could have no effect whatever since all of these wires are, in effect, the same wire constituting one side of the line. As previously stated, only shunt connection between the wires 56 and 57 and wires 72 and 73 would result in a short circuit and burn the fuse 43.

From the foregoing, it will be apparent that the present system is highly advantageous for the reason that any fraudulent use of current will result in the complete breaking of the circuit in a manner which will be unknown to the vast majority of consumers, and the automatic switch which breaks the circuit is not accessible and requires the services of an employee of the power company in order that service may be restored in the building. Thus the system acts as a positive means for preventing fraudulent use of current and requires that the power company be given knowledge of the attempt to fraudulently use current before service can be restored. Thus the power company is efficiently protected against the losses and is not required to even locate the means through which the current consumer has attempted to defraud the meter. Any person attempting to use the current fraudulently will be aware that he has in fact notified the power company of his actions through the necessity of having to secure the services of an employee of the company to restore the normal circuits, and it is hardly probable that he will make a second attempt of the same kind. Any further attempt to secure the same results by some different means of shunting the meter or tapping the wires ahead of the meter will have the same result.*

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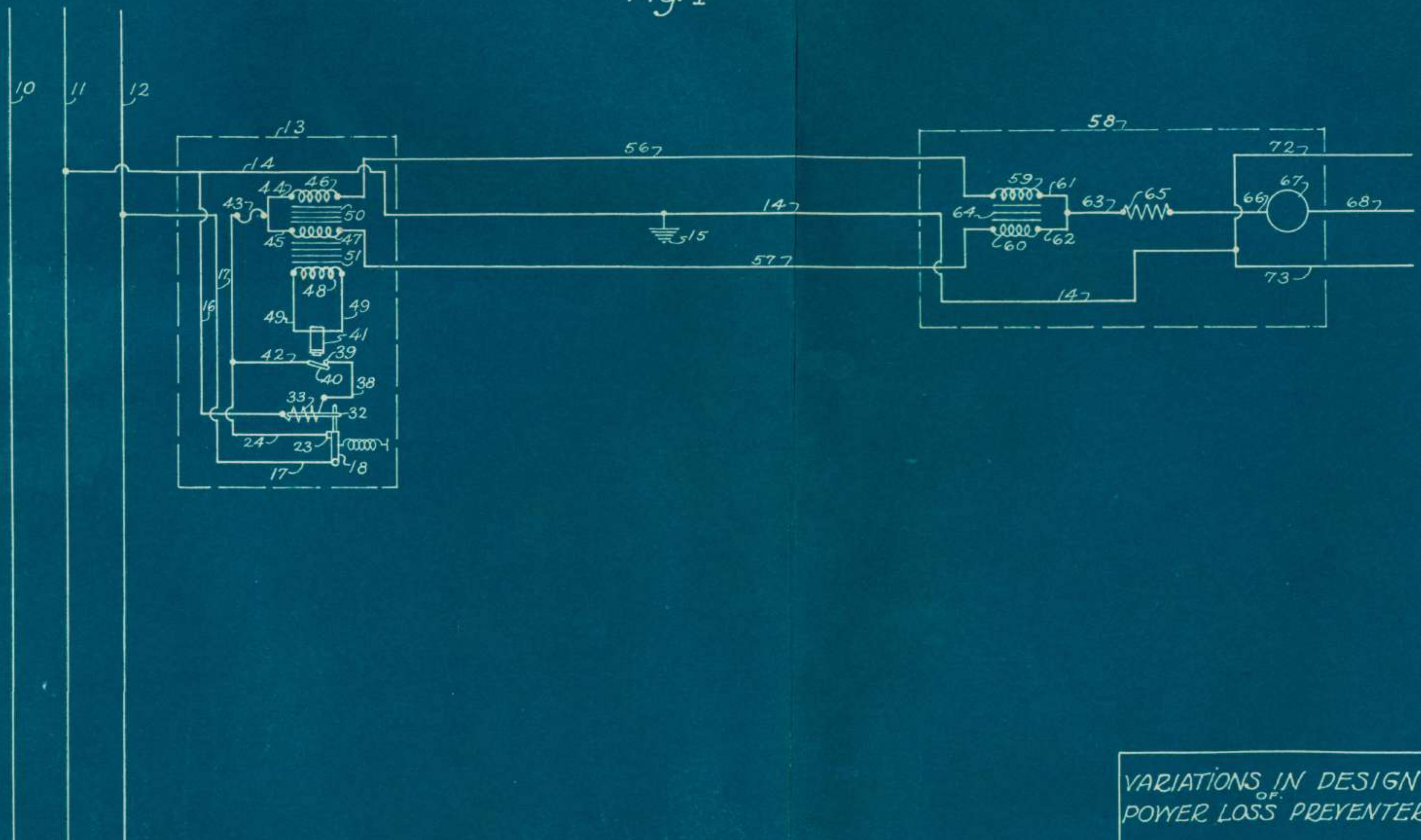
* End of description quoted from pat. #1,987,153.

Fig. 1



VARIATIONS IN DESIGN OF POWER LOSS PREVENTER

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The form shown in Figure 1 works very satisfactorily, but is capable of being much simplified. Figure 2 shows the relay system simplified almost as much as possible. The general method of operation remains the same but the details vary enough to require an explanation of it also.

The circuit diagram for a 110 volt installation is shown on the accompanying diagram, Figure 2. All figures and numbers used in the following discussion correspond with those in the diagram.

Current flows from line 3 (one of the power mains) through line 4, through fuse 5, up to the junction of balanced differential coils 10 and 11 -- these coils are really one continuous coil tapped at some point -- the current continues through lines 15 and 18 into another pair of similar coils 21 and 22, through resistance 24 and meter 26, through the load (not shown), and returns through line 27 and 29 and 16, which is neutral.

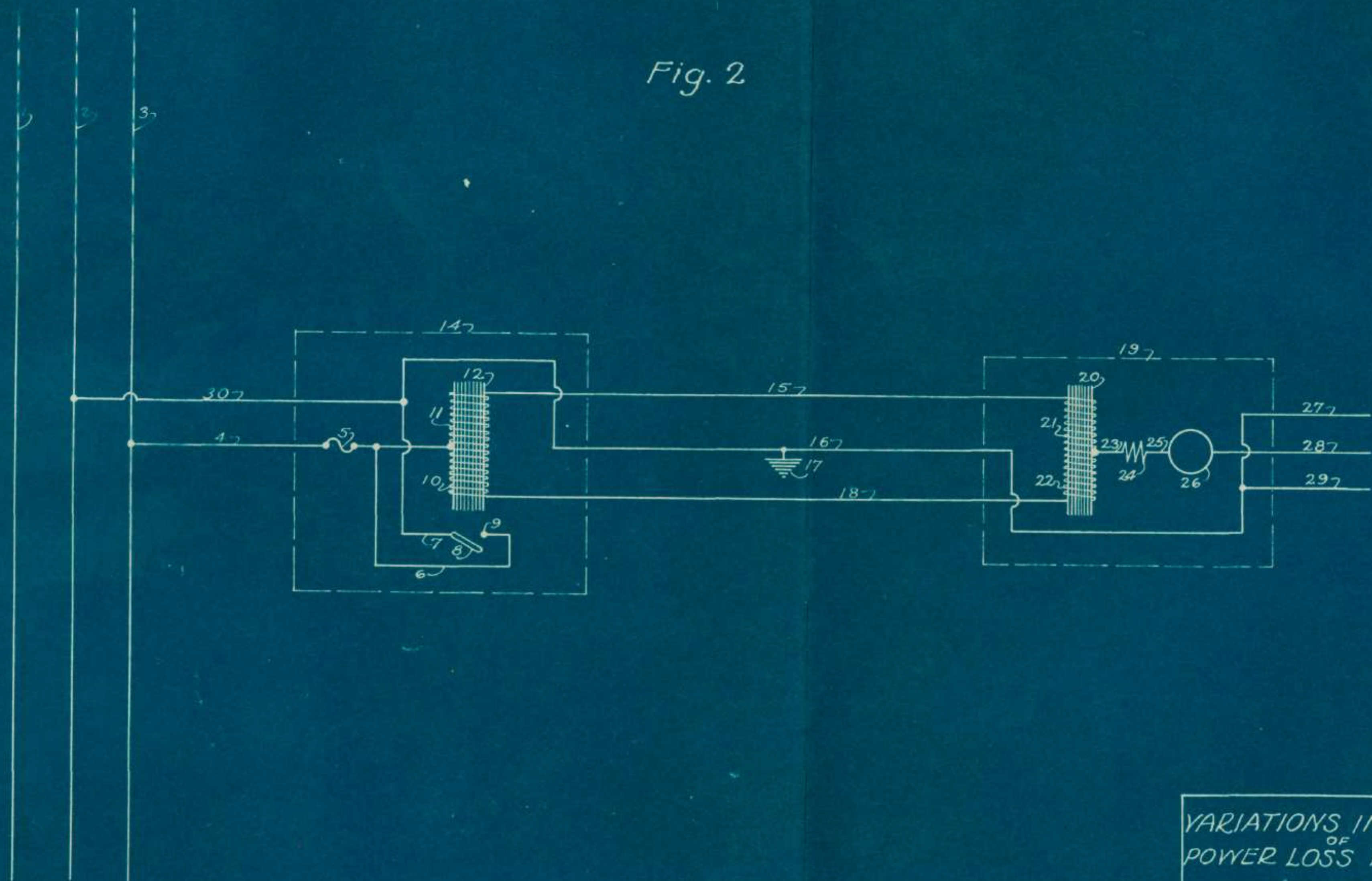
Because the two sets of coils are similar and tapped at corresponding points, and due to their differential construction, the currents in lines 15 and 18 divide inversely as the number of turns in coils 10 and 11 or 21 and 22, and there is no flux in either core 12 or 20. The system as described is very stable, and without tampering will not become unbalanced.

Now consider what happens under the following conditions: Say that a load is connected between either of the lines 15 or 18 and line 16 (tapping off ahead of the meter). For this illustration we shall use line 18.

The current tends to divide in coils 10 and 11, as under normal conditions, but the current in line 15 is now choked by the coils 21 and 22 which act in series under this condition since the current must flow through these coils in order to reach the stolen load. Therefore, practically all the stolen load current takes the easier path through the coil 10 and line 18, thus setting up a flux in core 12 which actuates the armature 8. This movement of the armature 8 makes contact at 9, short circuiting the line and blowing fuse 5, thus opening the circuit.

Now consider the case when the meter is shunted by a connection from 18 to 28. When this is done, coil 22 is short circuited and coil 21 is not. This connection results in coil 22 being the short circuited secondary of a current transformer of which coil 21 is the primary. Therefore, the ampere turns of the coil 22 would be equal and opposite to those of 21 (neglecting the very small magnetizing ampere turns of coil 21), which is exactly the same as though coil 22 were not short circuited. However, due to the small resistance 24, we do not have a pure short circuit of coil 22. Due to this resistance, the generated short circuit current is reduced, thereby destroying the magnetic balance which existed in core 20. Since a flux appears in the core 20, it causes coil 21 to act as a choke, and thus reduces the current in line 15, which changes the current ratio in lines 15 and 18. This causes the relay system to operate as previously described.

Fig. 2



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OF
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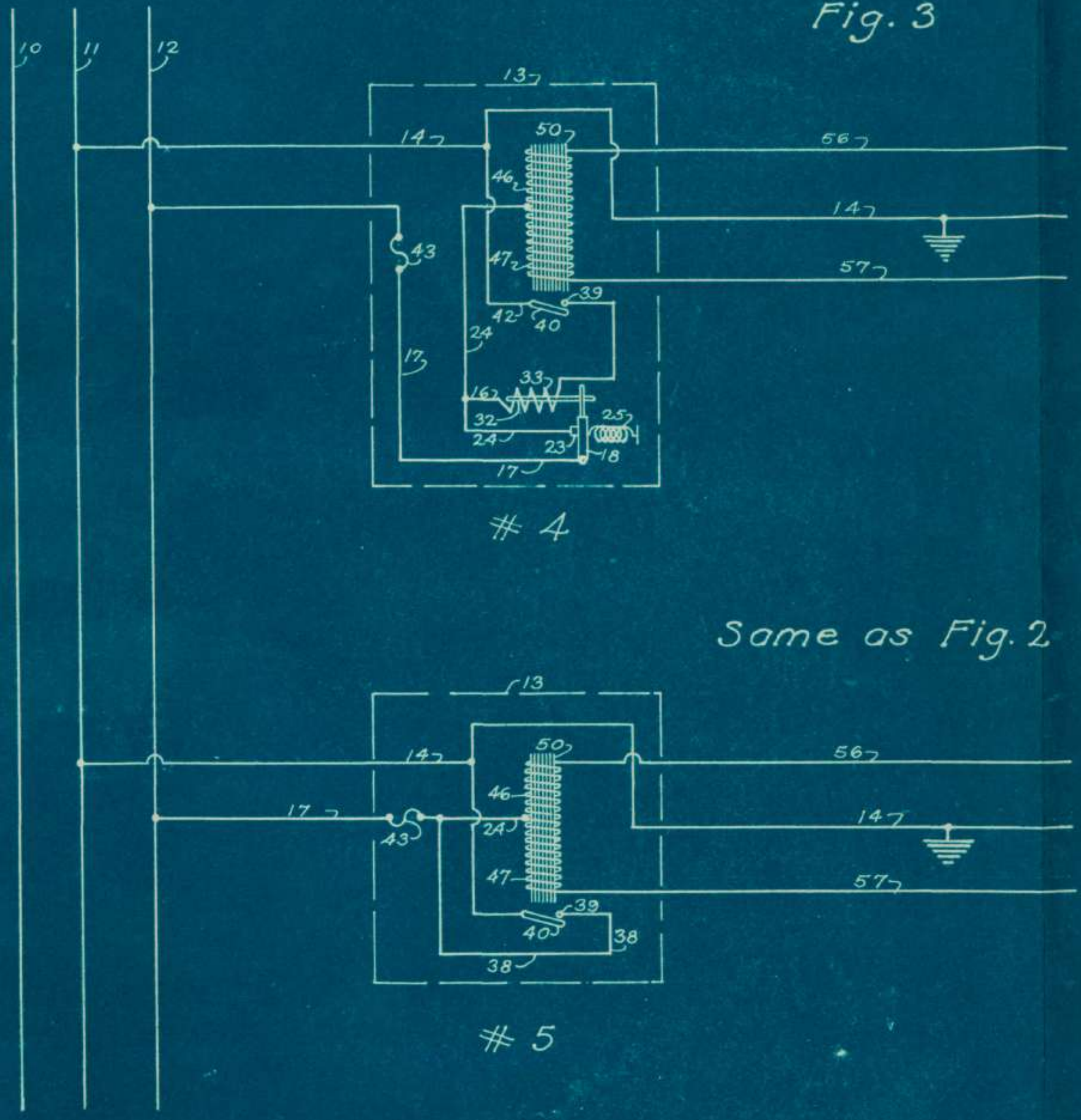
Figure 3 is still another variation of Figure 1, which in actual practice has proven to be more satisfactory than Figure 2. The form of the device shown in Figure 2 is subject to burned contacts at 39 and 40 or 8 and 9, depending upon which diagram is referred to. Figure 3 solves this problem, as the switch 18 opens so swiftly that no arc forms. Figure 3 is very similar to Figure 1, so that a separate explanation of its operation is unnecessary.

Fig. 3



The Rest of the Circuit is as shown in Fig. 1

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Figure 4 is a very decided improvement on the previous forms of the device, because by using this variation, the size of the differential coils may be reduced two-thirds and at the same time the system is proof against some methods of electrically stealing energy to which the previous variations would not respond.

The circuit for a 110 volt installation is shown on the accompanying diagram. All figures and numbers used in the following discussion correspond with those in the diagram.

Current flows from line 17 (one of the power mains) through contact 1, switch S, contact 2, up to 3, the junction of balanced differential coils collectively called M, continues through lines 14 and 15 into another pair of similar coils collectively called N, through the meter W, to the load (not shown) and returns through line 16, which is the neutral.

Because the two sets of coils are similar and due to their differential construction, the currents in lines 14 and 15 divide inversely as the number of turns in each coil of M or of N and there is no magnetic flux in either the core of M or of N. The system as described, is very stable and will not become unbalanced without tampering.

Before considering the operation of the device under abnormal conditions, it is necessary to understand the operation of the relay in the lower portion of the space enclosed by the dotted line T. The relay consists of a heater coil H and a bi-metallic strip C which moves J first in the direction of A, and then towards B. When C is cool, J is in the direction of A and the contacts 7 and 8 are connected. Current flows from line 15 to contact 8, then to 7, to 10, on to heater H and then to 12 and 13 where it joins the neutral line 16. This current energizes one of the coils of M and so causes the relay R to make contact with 9. Otherwise, the current would also flow through R to 11, to heater K, then to 12 and so on to line 16. When K is energized, the bimetallic strip D moves, releasing the switch S which is biased to open position by a spring. (Details of a mechanical nature are not shown on this diagram, which is purely to show the electrical circuit). However, the relay R prevents any such action by rising and making contact at 9, as previously stated.

Thus, if J is toward A which connects 7 and 8, nothing happens to cause the switch S to open. The heater H is actuated as previously explained and is so designed that J remains in contact with 7 and 8 about 15 or 18 seconds until C becomes heated sufficiently to move J towards B, thus cutting off the current from the heater H. J moves towards B and makes contact with 5 and 6. This connects contact 9 to the points 6 and 5 and so to contact 2 on the dead side of the switch S. But just as soon as J moves toward B, the armature R drops down and then contacts 10 because the current heating H has been interrupted. Therefore, the heater K is still unenergized and switch S remains closed. Bi-metallic strip C is so designed, along with the heater H, that it will move J towards B every 20 or 30 minutes, for C will move J back towards A when it cools, where it will again repeat the cycle.

Now, when the meter W is shunted in any manner around the box V, and J is contacting 7 and 8, the differential coils of M neutralize each other and the armature R does not move to 9 but remains at 10. Then current flows through R to 11, to heater K, then to 12 and so on to line 16. Because of the heat from K, the bi-metallic strip D moves, releasing the switch S, thus interrupting service when fraud is attempted.

If, at a later time, a load is connected between either of the lines 14 or 15 and line 16 (tapping off ahead of the meter), for this illustration say line 15, one of the coils of M will be energized. The other coil will not be energized because of the coils of N which act in series under this condition. As mentioned before, the current tends to divide in the differential coils of M and lines 14 and 15, but the current in line 14 is now choked by the coils of N since the current must flow through these coils in order to reach the stolen load. Therefore, practically all of the stolen load takes the easier path through line 15, thus setting up a magnetic flux in the core upon which M is wound. This flux actuates the armature R, causing it to rise and contact 9.

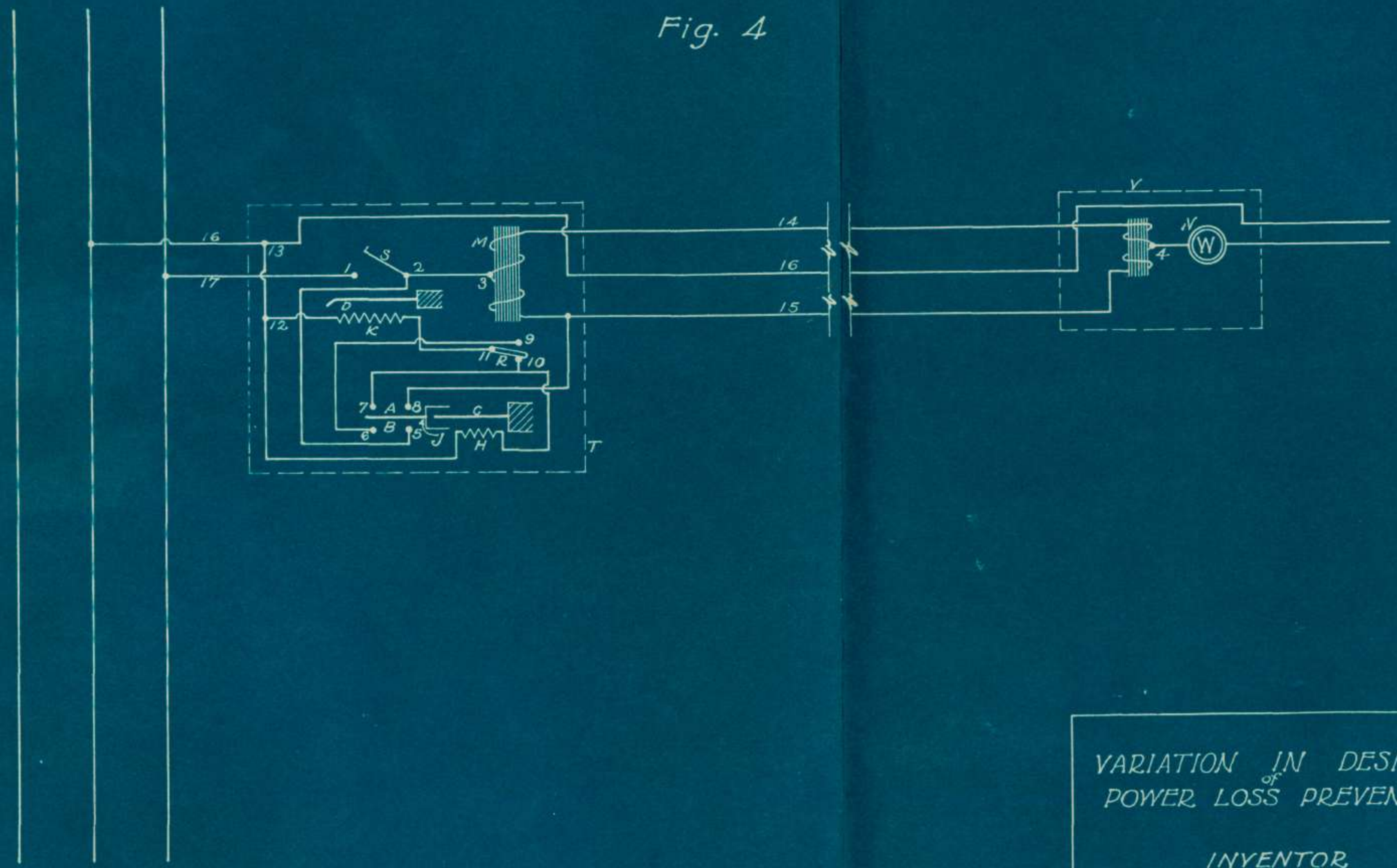
Now, returning to the relay, if J is towards A which connects 7 and 8, nothing happens to cause the switch S to open. The heater H is actuated as previously explained and is so designed that J remains in contact with 7 and 8 about 15 or 18 seconds. Heater K is so designed that it will cause switch S to open in about 8 seconds when energized.

After 15 or 18 seconds, C becomes sufficiently heated to move J towards B, thus cutting off the current from heater H. When J makes contact with 5 and 6, the circuit is closed from 9 to the heater K so current flows from 12 through K to 11, then to 9, then to 6 and across to 5, and then to 2, thus completing the circuit causing K to heat the bi-metallic strip D and to open the switch S.

With this arrangement, the power circuit is tested two or three times every hour, first for shunts on the meter, then for tapping off ahead of the meter. The longest time power can be diverted from the meter is 20 or 30 minutes while the average time is only 10 or 15 minutes.

Some of the more common methods of energy diversion and the protection this device offers against them have been discussed. As for tampering with the meter itself, the system can be so wired that the switch will operate when the cover is removed, if it is so desired. This would give positive seal protection.

Fig. 4



VARIATION IN DESIGN
of
POWER LOSS PREVENTER

INVENTOR
H.T. YOPP

The foregoing discussion of Figure 4 completes the treatment of the electrical relay system to prevent energy diversion. However, to get the best results, it has to be used in conjunction with a meter that is as mechanically tamper proof as possible. The Westinghouse socket type KWH meter comes nearest to this ideal. But even this meter has one weak point. The cover is such that a hole can be bored through it with a small drill. The writer has devised an improved glass cover for this type of meter, although it will operate equally as well on all types. A discussion of this glass meter-cover follows on the next page.

TAMPER PROOF METER COVER

In recent years, one form of electrical energy diversion has consisted of drilling minute holes in the glass covers of KWH meters through which objects, such as pins, horsehairs, etc., rest upon the rotating disc of the meter, thus slowing or stopping it. It has been found from experience that the detection of such holes when skillfully drilled is very difficult, and even then the practice goes on for months before the trouble is found and corrected.

Within the last three years, considerable attention has been devoted to the mechanical protection of the meter by alert public utilities. Meter boxes, both for outside and inside use, have been developed, in which the meter is totally inclosed. More recently, the Westinghouse Electric & Mfg. Company introduced its S type socket meter. This is an assembly of parts whereby any standard meter, from 1915 to date, may be converted into a much more theft-proof device. In brief, the meter mechanism is mounted and wired to a panel which is plugged into a cast iron bowl or receptacle as a radio tube is plugged into its socket. Then a glass meter cover is put over the meter and locked with a special locking ring and seal. The iron receptable is threaded at top and bottom for conduit and fits into the conduit circuit at any desired point.

The socket type meter is really a forward step in metering. With it mechanical tampering is much more difficult, about the only way left is by means of objects, inserted in holes bored in the meter glass cover, that retard or stop the rotating disk.

The cover described in this paper, when used with the socket type meter or a well designed meter box, makes mechanical tampering almost impossible without instant detection by the meter reader when he makes his monthly visit. Refer to the accompanying diagram. The cover is similar to a wide, flat bottomed thermos bottle with no neck and with a height about one-third of normal. As in a thermos bottle, the cover is double walled. The space between walls is filled entirely with nitrogen, carbon dioxide, or is evacuated. Before sealing, a liquid is sprayed in this space or a small amount poured in. The liquid is one that oxidizes rapidly upon exposure to air, turning black, brown, or some other color, depending upon the exact chemical used. There are several cheap chemicals that are suitable, ferrus tannate being one that is colorless until exposed to air, when it soon turns black.

Referring to the diagram, 1 is the thick edge or rim of the cover, 2 is the outer wall, 3 the space between walls where the liquid is, 4 the inner wall, and 5 the front of the cover.

When a hole is bored in the meter cover, the air soon changes the liquid into a gummy black substance which discolors the walls upon which it is spread and the bottom of the sealed-in-space where some of the liquid is condensed. This is immediately noticeable by the meter reader, thus exposing the theft. An alternate method is to let the liquid be absorbed by small pieces of blotter and then to place the blotter in the sealed space. Then the white blotter will change color when a hole is made in the meter and air reaches it.

Still a third method is to fill the space between the glass walls with compressed air. Some simple pressure indicator is put into the walled space so that if the glass wall is punctured, the pressure inside will drop to the atmospheric level and will be shown by the pressure indicator.

This cover combined with the new developments previously discussed is, it seems, the solution to the problem of the prevention of mechanical tampering with power meters.

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FRAUD PREVENTING SYSTEM FOR ELECTRIC METERS

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Fig. 1.

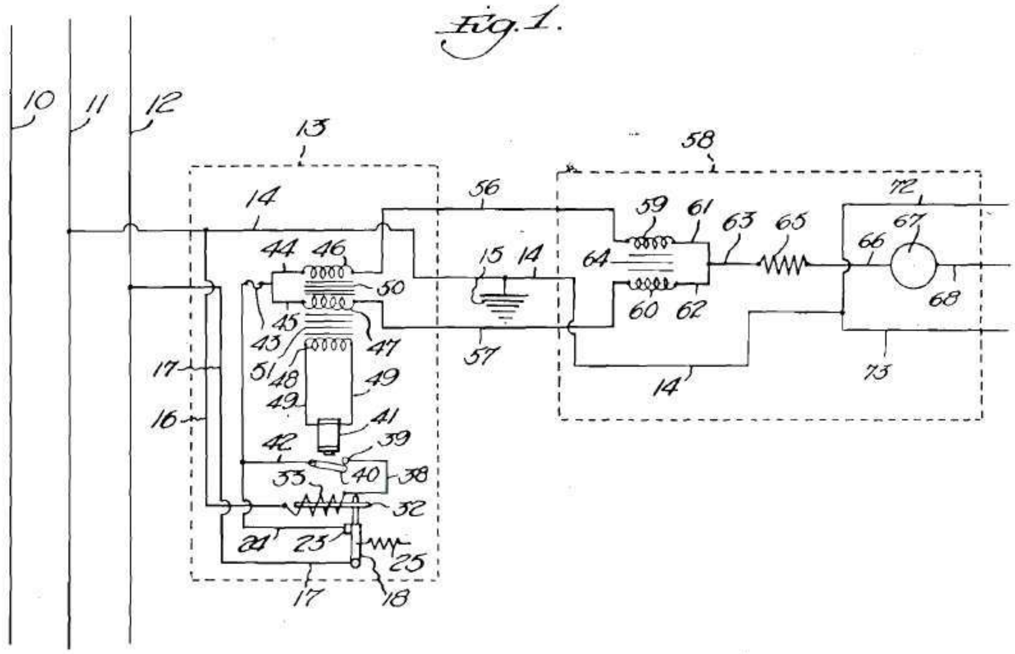

Fig. 2.

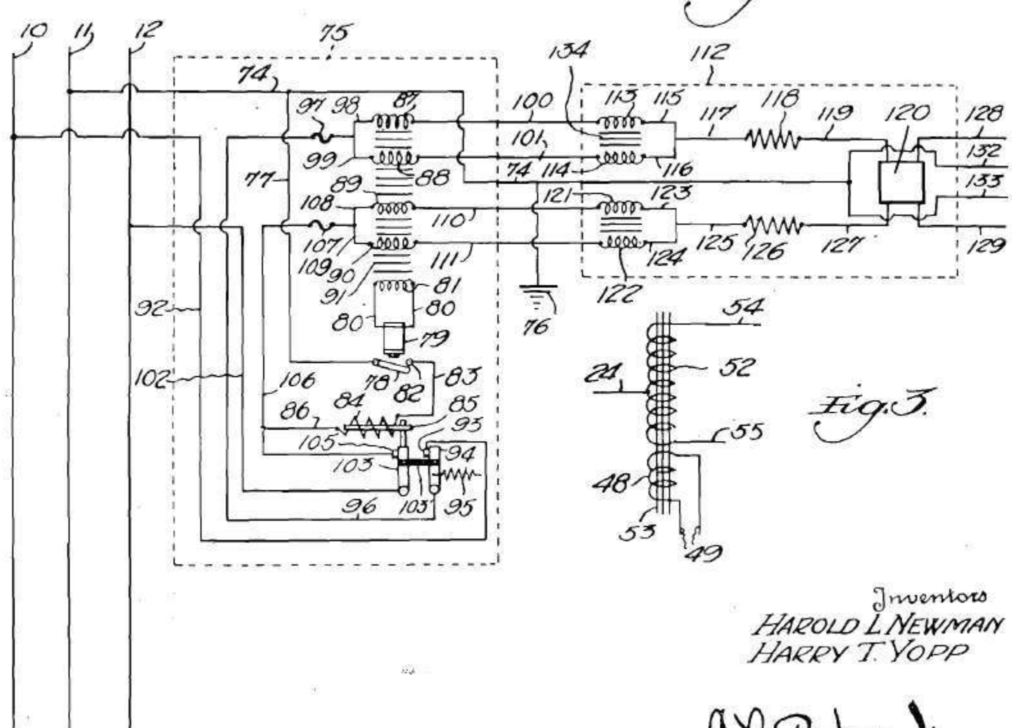

Fig. 3.

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Fig. 4.

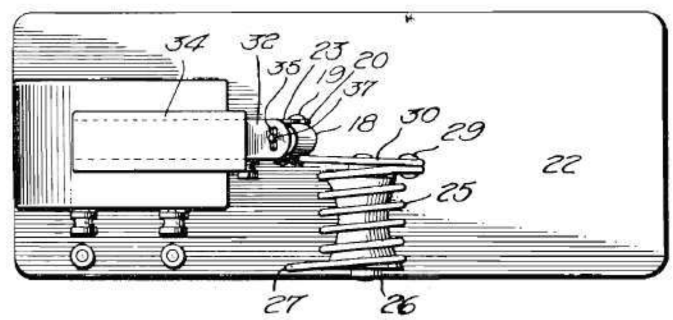
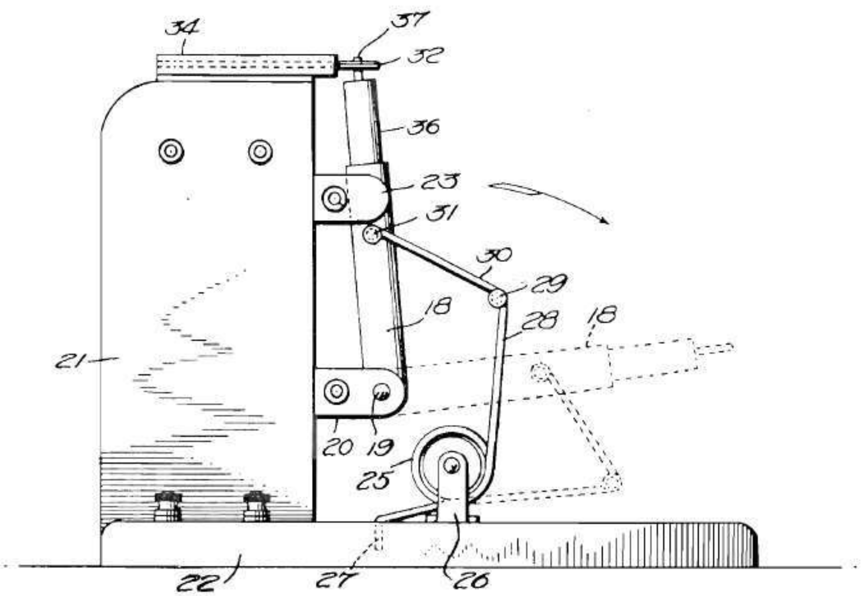


Fig. 5.



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1,987,153

FRAUD PREVENTING SYSTEM FOR ELECTRIC METERS

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Application April 19, 1933, Serial No. 666,922

17 Claims. (Cl. 171—34)

This invention relates to fraud preventing systems for electric meters.

It is well known that unscrupulous persons frequently resort to various means for preventing the metering of electric current consumed in homes and industrial buildings. Such fraudulent use of current may be accomplished in a number of ways the most common of which consist in shunting around the meter or tapping the wires ahead of the meter. These methods of fraudulently consuming electric current may be very easily practiced, it being merely necessary in the former case to connect lead wires around the meter to prevent the passage of current therethrough. With such system, none of the current consumed will be registered on the meter so long as the wires shunt around the meter, and it is the common practice for unscrupulous persons using such system to shunt around the meter only for a portion of the time between meter readings so that the fraudulent use of current will not be readily apparent.

The practice of tapping the lead-in wires ahead of the meter is quite prevalent since it provides means whereby a portion of the lights or other consuming devices of a building may be permanently supplied with current fraudulently obtained. The remaining current consuming devices of the building may be permanently supplied with current flowing through the meter so that the consumption of a regular portion of the current will be registered and fraud detection is thus rendered difficult. The method just referred to is particularly easy to practice in buildings where the line wires enter a substantial distance from the meter as, for example, in homes where the line wires enter through the attic while the meter is located in the cellar or basement. It is impossible to estimate the losses sustained by power companies through the fraudulent use of current, but it is well known that such losses are substantial and that they constitute a matter of serious consideration.

Numerous attempts have been made to prevent the fraudulent use of current but, so far as we are aware, such prior methods have been open to numerous objections which rendered their use largely undesirable or impracticable. For example, several of the prior methods suggested for this purpose have been disadvantageous because of the serious drop in potential across the meter involved, through the use of the current consuming means necessary for the operation of the system. Moreover, most prior systems do not prevent or indicate the use of current obtained by tapping the lead-in wire ahead of the meter, and most prior devices, if satisfactorily operable at all, merely indicate the fraudulent use of current without acting as a preventative. Such systems are of little practical use in view of the reluctance of power companies to make accusations of fraudulent use with no other evidence than the mere operation of an indicator which might be subject to accidental operation.

An important object of the present invention is to provide a novel system of preventing the fraudulent use of electric current by shunting around the meter or tapping the line wires ahead of the meter, or by any other of the known ways in which electric current may be fraudulently consumed.

A further object is to provide a system of the character referred to which is operative for positively disconnecting a house or other circuit from the line wires promptly upon the completion of an attempt to consume current which is not properly metered.

A further object is to provide a system of fraud prevention which includes an automatic switch inaccessible to the consumer and operable for disconnecting consuming circuits from the line wires when current is fraudulently consumed.

A further object is to provide a system of the character just referred to wherein the automatic switch is normally biased to open position and is released for movement to such position upon the fraudulent use of current, and which requires the services of an operator from a power company before the circuit can be restored.

A further object is to provide a fraud preventing system of the character indicated which is wholly practicable in operation without any appreciable drop in potential across the meter.

A further object is to provide a system of the character referred to which is operable with a minimum consumption of current, and wherein the current consumed does not pass through the consumer's meter.

A further object is to provide a fraud prevention system wherein divided circuits are employed which remain balanced during the consumption of current all of which passes through the meter, and which become promptly unbalanced upon a fraudulent attempt to consume current which does not pass through the meter, and to provide means operative upon the unbalancing of the circuits for disconnecting the consuming circuits from the line wires.

Other objects and advantages of the invention will become apparent during the course of the following description.

In the drawings we have shown several embodiments of the invention. In this showing,

Figure 1 is a diagrammatic view illustrating one form of fraud preventing system,

Figure 2 is a modified form of system,

Figure 3 is a detail diagrammatic view of a modified form of differential transformer,

Figure 4 is a plan view of an automatic switch particularly adapted for use in connection with the present invention, and,

Figure 5 is a side elevation of the same.

Referring to Figure 1, the numerals 10, 11 and 12 designate the usual line wires, the center wire 11 being the so-called "neutral" wire. In ordinary house and similar circuits, the difference in potential of 110 volts exists across the wires 10 and 11 and across the wires 11 and 12. The line wires referred to are adapted to supply alternating current, and it will become apparent that the system is operative for substantially any voltages, or for single or polyphase installations.

The numeral 13 designates a suitable box which may be mounted on the pole from which the feed wires lead into a building, although it will become apparent that the box may be mounted at any point inaccessible to the consumer. A wire 14 is connected to the neutral wire 11 and leads through the box 13, being grounded in accordance with standard practice at any suitable point as at 15. A wire 16 is tapped into the wire 14 within the box 13 for a purpose to be described.

In the present instance, current is supplied from the line wires through the wire 14 and through a second wire 17 connected to the wire 12 and leading into the box 13. The wire 17 is connected to the arm 18 of an automatic switch shown in detail in Figures 4 and 5. The switch arm 18 is pivotally connected as at 19 to a bracket 20 projecting outwardly from a block 21 preferably formed of insulating material and mounted upon a base 22, preferably formed of similar material. The switch arm 18 engages contacts 23 connected to a wire 24 to be referred to later. A relatively strong spring 25, preferably of the torsion type, is suitably supported by brackets 26 mounted on the base 22. This spring has one end 27 engaging the base 22 and has its other end 28 connected as at 29 to one end of a link 30. The opposite end of this link is connected as at 31 to the switch arm 18, preferably at a point spaced a substantial distance from the pivot 19. The spring 25 normally biases the switch arm 18 to the dotted line position shown in Figure 5.

A thermostat 32, preferably in the form of a bi-metallic strip, is mounted above the block 21 and is surrounded by a heating coil 33, as shown in Figure 1. This coil is encased as at 34, and the casing 34 is secured at one end to the upper end of the block in any suitable manner. The opposite end of the thermostat 32 projects beyond the edge of the block 21 and is provided with an opening 35. The switch 18 is provided at its upper end with a handle 36 of wood or other insulating material, and a pin 37 projects from the end of the handle 36. The pin 37 normally is arranged within the opening 35 to prevent the switch 18 from opening, and is released upon upward movement of the free end of the thermostat due to the heating thereof in a manner to be described.

As previously stated, one end of the heating coil 33 is connected to the wire 16, while the other end of this coil is connected by a wire 38 to a contact 39. This contact is adapted to be engaged by the armature 40 of a relay coil 41 upon energization of the latter in a manner to be referred to, and the armature 40 is connected by a wire 42 to the wire 24. If desired, a fuse 43 may be connected in the wire 42, and this wire divides as at 44 and 45 for connection respectively with the primary coils 46 and 47 of a differential transformer. This transformer has a secondary 48 the lead wires 49 of which are connected to the terminals of the relay coil 41. The differential transformer is illustrated as being provided with two cores 50 and 51, but it will be apparent that only one core is used in actual practice, and that the three coils of the transformer are wound on such core.

A somewhat modified form of transformer is illustrated in Figure 3, and this transformer is highly advantageous in use. A single primary coil 52 is wrapped on a core 53 and is provided with terminal wires 54 and 55, the wire 24 being tapped into this coil intermediate its ends. It will be apparent that the current through the wire 24 divides for passage through the two end portions of the coil 52 on opposite sides of the tap, and the primary is tapped preferably to one side of the center thereof for a purpose to be described. This form of transformer utilizes the same secondary coil 48 previously described.

Referring to Figure 1, the numerals 56 and 57 designate wires from the terminals of the primary coils 46 and 47 leading from the box 13. These wires, together with the wire 14, lead into a box 58 located in the building where the meter normally is arranged. The wires 56 and 57 are connected respectively to coils 59 and 60, and these coils have their other ends connected to wires 61 and 62 leading to a common wire 63 to which they are connected. The coils 59 and 60 are wound on a core 64.

The wire 63 leads to one end of a small resistance 65, and the other end of this resistance is connected by a wire 66 to a standard meter 67. A wire 68 leads from the meter, out of the box 58, into the interior of the building. The wire 14 leads into the box 58, as previously stated, and divides to form branch wires 72 and 73 leading from the box 58 into the interior of the building. It will become apparent that only one wire need lead from the box 58 in addition to the meter wire 68, but it is preferred that the branch wires 72 and 73 be employed in order that the number of wires leaving the box 58 may be the same as the number of wires entering the box. This arrangement is confusing to unscrupulous persons attempting to fraudulently obtain current, but it is not necessary that the load be balanced between the wire 68 and the respective wires 72 and 73. In other words, any desired loads may be connected across the wire 68 and the respective wires 72 and 73 for the legitimate use of current without causing operation of the present invention to open the main circuit.

In standard supply circuits a difference in potential of 110 volts exists across the line wires 10 and 11 and across the wires 11 and 12 and the system illustrated in Figure 1 is operative where the consumer's circuit is supplied across either the wires 10 and 11 or the wires 11 and 12. In Figure 2 of the drawings the system is illustrated as applied to a 220 volt three wire installation. In such system the theory of operation to be referred to later is identical with that of the system illustrated in Figure 1 except that the parts are largely duplicated. Referring to Figure 2, a wire 74 leads into a box 75 similar in construction and location to the box 13. The wire 74 leads from the box 75, as shown, and is suitably grounded as at 76. Within the box 75, a wire 77 is connected at one end to the wire 74 and has its other end connected to the armature 78 of a relay coil 79. The terminals of the relay coil are connected by wires 80 to the terminals of a differential transformer secondary coil 81, similar to the coil 48 previously described. Upon energization of the relay, the armature 78 is attracted into engagement with a contact 82 connected to one end of a wire 83, and the other end of this wire is connected to one terminal of a heating coil 84. This coil surrounds a thermostat 85, preferably of the bi-metallic strip type, and the other end of the heating coil is connected to a wire 86.

The differential transformer in Figure 2 is provided with two pairs of primary coils, the first pair being designated by the numerals 87 and 88, and the second pair by the numerals 89 and 90. The primary coils are all wound preferably on the same core 91. A wire 92 is connected to the line wire 10 and leads to a contact 93 normally engaged by a switch arm 94. The switch arm is normally urged away from the contact 93 by a spring 95, and is held in engagement with the contact in a manner to be described. A wire 96 is connected at one end to the switch arm 94 and preferably has a fuse 97 arranged therein. Beyond the fuse, the wire 96 is connected to branch wires 98 and 99 connected respectively to the coils 87 and 88, and these coils have lead wires at their other ends leading from the box 75 as indicated by the numerals 100 and 101.

A wire 102 is connected to the wire 12 and leads to a switch arm 103 similar to the switch arm 94 and normally engaging a contact 105. The switch arm 103 is identical with the arm 18, having an upstanding finger engaging the thermostat 85 to normally hold the switch in closed position. The switches 94 and 103 are connected by a link 103', preferably formed of insulating material, to cause simultaneous movement of the switch arms. The contact 105 is connected to one end of a wire 106, and the wire 86 is connected to the wire 106 intermediate the ends thereof. A fuse 107 is preferably connected in the wire 106, and beyond the fuse the wire 106 is connected to branch wires 108 and 109 leading to the coils 89 and 90. The other ends of these coils are connected respectively to the wires 110 and 111 leading from the box 75.

The wires 74, 100, 101, 110 and 111 lead into a box 112 similar to the box 58 previously described. The wires 100 and 101 are connected respectively to coils 113 and 114 having their ends leading to branch wires 115 and 116 connected to a common wire 117. This wire leads to one end of a resistance 118, from which current passes over wire 119 to a meter 120.

In a similar manner, the wires 110 and 111 lead to coils 121 and 122 having their ends connected to branch wires 123 and 124 connected to a common wire 125. This wire, in turn, leads to one end of a resistance coil 126 from which a wire 127 leads to the meter 120. "Hot wires" 128 and 129 lead from the meter and from the box 112, as shown. The neutral wire 74 leads into the box 112 and is connected to branch wires 132 and 133 leading from the box 112. The coils 113, 114, 121 and 122 may be wound upon a single core 134.

The operation of the system illustrated in Figure 1 is as follows:

As previously stated, the system operates on alternating current, and the present description will be based on the assumption that the current is flowing in one direction. In other words, the operation during the flow of one current impulse will be described. The current flows from line wire 12 through wire 17 to the switch arm 18 which is normally held in closed position against the tension of the spring 25 by the thermostatic element 32. Accordingly current will flow through contact 23, wire 24 and fuse 43, and thence through the branch wires 44 and 45 and their respective primary coils 46 and 47. The ampere turns of these coils are equal and opposite whereby they neutralize each other, and accordingly no net flux will be generated in the core of the differential transformer and the magnet 41 will be deenergized. Under such conditions, the armature switch 40 will remain open and no current will flow through the heating coil 33.

The current obviously divides through the coils 46 and 47 and then flows through wires 56 and 57, coils 59 and 60 and wires 61 and 62. These wires are connected to the common wire 63, and current flows through this wire, through resistance 65, wire 66, meter 67 and wire 68. The flow of current described takes place if a load is connected across the wires 68 and 72, across wires 68 and 73, or across both sets of wires.

After passing through the load, the current returns through wires 72 and/or 73, wire 14 and neutral wire 11. The ampere turns of the coils 59 and 60 are equal and opposite whereby the coils neutralize each other, and thus no net flux flow will be set up in the core of the differential choke coils. The drop in potential across the outlet wires due to the use of the small resistance 65 is negligible.

As previously stated, the present system is unaffected by the relationship of the loads connected across the wire 68 and wire 72 and across the wires 68 and 73, but a wholly different result follows if an unscrupulous person attempts to utilize current which is not metered, either by shunting around the meter or by tapping the wires ahead of the meter. As previously stated, the box 58 is located within the building or at any point where the meter ordinarily would be placed, while the box 13 is arranged at an inaccessible point, preferably on the light pole. For connecting the elements within the two boxes, it is desirable in practice that a two conductor concentric cable be employed to render it more difficult to tap the wires, although the operation of the system is not dependent on the use of any particular form of lead wires.

If an unscrupulous person attempts to shunt around the meter, there will be no way in which he can determine which wires to connect, and if either of the wires 56 or 57 is connected to either of the wires 72 or 73, a short circuit obviously will result, thus immediately burning out the fuses. The same result will follow if an attempt is made to connect the wires 14 and 68. If a load is connected across either the wires 14 and 57 or 14 and 56, no fuses will be blown, but the switch will be caused to open.

Assuming that a load is connected across the wires 14 and 57, it will become apparent that the coils 46 and 47 will be immediately unbalanced, thus generating a flow of flux through the core of the differential transformer. Under the conditions referred to, current at a given instant will flow through the primary transformer coil 47, through wire 57, through the load and thence through the neutral wire 14. At the same time, current will flow through transformer coil 46, wire 56, through the coils 59 and 60 in series, through wire 57, through the load and thence through wire 14. As previously stated, the ampere turns of coils 59 and 60 are equal and opposite and this is true during legitimate use of current at the outlet side of the meter, but under the conditions being considered, the effects of the coils 59 and 60 would be added to each other, whereby both act as choke coils. This double choking effect would occur in the circuit of the primary coil 46, whereas substantially no resistance would exist in the circuit of coil 47, and thus the coils 46 and 47 would be unbalanced. This condition would cause the flow of a net flux in the core of the transformer to generate a current in the circuit of the secondary coil 48. The relay coil 41 will then become energized to attract its armature 40, thus moving the latter into engagement with the contact 39 to close the circuit through the heating coil 33. This circuit is closed through wire 17, switch 18, wires 24 and 42, through the switch 40, wire 38, coil 33, and wires 16 and 14.

The closing of this circuit obviously heats the coil 33, and the thermostatic element 32 is caused to bend upwardly to release the upper end of the finger 37, whereupon the spring 25 moves the switch 18 to open position. The entire circuit to the building thus will be opened, and since the consumer of the current has no access to the box 13, he cannot restore the circuit but is forced to notify the power company in order that an operator may be sent out to open the box 13 and close the switch 18. In actual practice, it has been found that the switch 18 will open if an unbalanced load of the character referred to remains in operation for approximately three seconds.

Assuming that the primary coils 46 and 47 are separate coils, their windings obviously will neutralize each other. If such system is employed, it will be apparent that equal loads may be simultaneously connected across the wires 14 and 56 and wires 14 and 57 without unbalancing the coils 46 and 47, in which case the system would not operate. Such loads, however, would have to be simultaneously connected since, as previously stated, the switch 18 opens in approximately three seconds after the balance between the coils 46 and 47 is disturbed. Moreover, the use of almost exactly equal loads across the wires 14 and 56 and 14 and 57 would be required to prevent the opening of the switch 18, and such fraudulent use of current would be highly impracticable.

The transformer shown in Figure 3 is such that the system will operate perfectly if equal loads are connected across the points indicated. A single primary coil 52 is employed, and the wire 24 is tapped into the coil 52 intermediate the ends of the latter and at a point spaced from its center. Under such conditions, the two primary coils thus provided will be equal in ampere turns if loads are connected in the circuit beyond the meter. These primary coils, however, will be promptly unbalanced by having their ampere turn relationship destroyed if a load is connected, for example, across the wires 14 and 57, thus generating a flux flow to induce current in the secondary coil 48. In view of the fact that the wire 24 is not tapped into the coil 52 centrally thereof, current cannot be fraudulently used by connecting equal loads across the wires 14 and 56 and 14 and 57, and such fraudulent use of current could be obtained only by employing respective loads bearing the same relationship as the turns of the two primary coils into which the coil 52 is divided. The relationship between the primary coils of the transformer shown in Figure 3 is not subject to any particular limitations and may be of such character as to make it substantially impossible to employ loads ahead of the meter in the same ratio as the primary transformer coils. For example, the turns of the primary coils may be in the ratio of 2 to 1, 2½ to 1, 2⅞ to 1, etc., and if desired, different apparatus may be made with primary transformer coils of different ratios.

If an attempt is made to use current fradulently by shunting around the meter by a wire connected between the wire 68 and either wire 56 or 57, a disturbance in the normal flow of current will occur to unbalance the coils 46 and 47 and thus cause the relay coil 41 to be energized to break the circuit through the switch 18. For example, if a shunt is connected between the wire 56 and the wire 68, the coil 60 becomes the primary coil of a current transformer upon the connection of a load across the wire 68 and, for example, the wire 72. Under such conditions, current will flow through coil 60, wires 62 and 63, resistance 65, through the wire 66, meter 67, wire 68 and through the load, and thence through wire 72, and wire 14. The coil 60 thus generates a current through the coil 59 and its associated wires and through the shunt connected around the box 58, and if the resistance of such secondary circuit were substantially zero, the secondary current would be substantially equal to the primary current in the circuit of the coil 60. Under such conditions, there would be no net flux in the core 64, and the coils 59 and 60 would remain balanced. In other words, such result would follow if the shunt were connected between the wires 56 and 63, but the latter wire is not available for the reason that it is enclosed within the box 58, and a shunt around the meter box accordingly necessarily includes the resistance 65 if the shunt is connected in the manner previously described, namely, between the wires 56 and 68. The resistance 65 is relatively low, and its effect on the current flowing through the coil 60 is negligible. However, the introduction of the resistance into the circuit of the coil 59 and the shunt connected around the meter box reduces the secondary current generated in such circuit by the primary coil 60.

Of course, the current flowing over wire 56 divides through the shunt wire and the coil 59, but this does not affect the reduction of the net current in the circuit of the coil 59 and the shunt connection, since the greater the normally divided current that flows through the coil 59, the less will be the current through the coil 59 generated by the primary coil 60. The unbalancing of the coils 59 and 60 thus results in the generation of flux in the core 64 whereby the coil 60 is caused to act as a choke to reduce the current in the line including the differential transformer coil 47 and the coil 60. The reduction in the resistance of the circuit including the coil 46 and wire 56 through the use of the shunt connection thus results in the substantial unbalancing of the coils 46 and 47 whereupon flux is generated in the differential transformer core to cause the generation of current in the circuit of the secondary coil 48 and its relay 41. Under such conditions the circuit through the switch 18 will be broken in the manner previously described.

The foregoing result covers the shunting across the wires 56 and 68, and obviously the same result would follow the connection of a shunt wire between the wires 57 and 68. The only difference would be that the coil 59 would become a transformer primary coil to generate current in the circuit including the coil 60 and the shunt connection, whereupon the coil 59 would act as a choke and the coils 46 and 47 would become unbalanced. Obviously a shunt between the wire 14 and either of the wires 72 and 73 could have no effect whatever since all of these wires are, in effect, the same wire constituting one side of the line. As previously stated, any shunt connection between wires 56 and 57 and wires 72 and 73 would result in a short circuit and burn the fuse 43.

The operation of the system illustrated in Figure 2 is similar to the operation of the system previously described and need not be referred to in detail. It will be apparent that a difference in potential of 110 volts exists across the wires 128 and 132 and across the wires 129 and 133, the difference in potential across the wires 128 and 129 being 220 volts in accordance with standard three wire installations. Any attempt to fraudulently consume current with such system will result in the opening of the circuits in the box 75 as in the previous case. For example, a load across the neutral wire 74 and either wire 100 or 101 will unbalance the coils 87 and 88, while the coils 89 and 90 will be unbalanced by introducing a load across the wire 74 and either wire 110 or 111. The unbalancing of either pair of primary coils generates a flux in the transformer core to induce current in the circuit of the secondary coil 81, thus energizing the relay coil 79 and moving the armature 78 into engagement with the wire 82. This action closes the circuit through the heating coil 84 to move the thermostatic element 85 upwardly, and release the switch 103, this switch being identical with the switch 18 previously described. The divided circuits through the primary coils 87 and 88 receive their current through the switch arm 94, while the switch 103 is in the line of the primary coils 89 and 90. The two switches referred to are connected together for simultaneous operation, and since the thermostatic element 85 will be operated upon the unbalancing of either pair of primary coils, both switches 94 and 103 will be opened by the spring 95 upon any attempt to consume current fraudulently.

From the foregoing, it will be apparent that the present system is highly advantageous for the reason that any fraudulent use of current will result in the complete breaking of the circuit in a manner which will be unknown to the vast majority of consumers, and the automatic switch which breaks the circuit is not accessible and requires the services of an employee of the power company in order that service may be restored in the building. Thus the system acts as a positive means for preventing fraudulent use of current and requires that the power company be given knowledge of the attempt to fraudulently use current before service can be restored. Thus the power company is efficiently protected against losses and is not required to even locate the means through which the current consumer has attempted to defraud the meter. Any person attempting to use current fraudulently will be aware that he has in fact notified the power company of his actions through the necessity of having to secure the services of an employee of the company to restore the normal circuits, and it is hardly probable that he will make a second attempt of the same kind. Any further attempt to secure the same results by some different means of shunting the meter or tapping the wires ahead of the meter will have the same result.

While the movement of the thermostatic element 32 may be utilized merely as a signal to the power company of the attempt to consume current fraudulently, it will be apparent that the most efficient results are obtained by utilizing the thermostatic element as means for releasing an automatic switch whenever an attempt is made to consume current which does not flow through the meter. The parts of the apparatus are relatively inexpensive to manufacture and obviously the apparatus will save its cost to a power company many times over by preventing unscrupulous persons from consuming current for which they do not pay. Since only a small proportion of the users of electric current attempt to employ fraudulent means for securing current without cost, it is not contemplated that the present apparatus be connected in the service lines of all consumers, but only in lines where a power company suspects that fraud is being practiced.

While the apparatus has been described particularly as a system for preventing the fraudulent consumption of electric current, it will be noted that it possesses particular value in removing fire hazards. For example, if a ground occurs in lines 56 or 57 of as much as half an ampere, the unbalancing of the coils 46 and 47 will be sufficient to operate the relay and release the switch 18. This result occurs in the same manner as when an unscrupulous person taps the lines ahead of the meter. The portions of a building beyond the meter ordinarily are protected by fuses, but normally the lines between the meter box and the pole are not so protected, and many fires originate through the grounding of the line wires ahead of the meter. Accordingly the present device serves as a fire prevention means. A linesman, called out to reset the switch 18 will find that the switch will not remain closed if either of the lines 56 or 57 is grounded, and accordingly he will seek to find the cause of the operation of the relay 41, and accordingly will locate the ground.

The electrical values of the various portions of the apparatus are not critical, and the design of the parts depends largely upon the loads at which it is desired to have the switch 18 open. For example, in one embodiment of the apparatus, the coils 59 and 60 have been wound with forty and eighty turns respectively in which case a load of 60 watts connected across the line ahead of the meter is sufficient to operate the relay 41. If the resistance 65 is of the order of 0.2 ohm under such conditions, a load of 260 watts or more connected across the wire 68 and either wire 72 or 73, with the meter shunted in the manner previously described, will result in the operation of the relay 41. Obviously the loads at which the switch 18 will open, may be varied by changing the values of the various elements.

It is to be understood that the forms of the invention herewith shown and described are to be taken as preferred examples of the same and that various changes in the shape, size and arrangement of parts may be resorted to without departing from the spirit of the invention or the scope of the subjoined claims.

We claim:

1. A system of the character described comprising a pair of electric transmission lines, one of said lines being divided to form a pair of branches, a transformer including a pair of balanced primary coils arranged in the respective branches and a secondary coil, a pair of balanced choke coils arranged in the respective branches, a power theft detecting device, an auxiliary circuit including said secondary coil, and means operable upon the generation of a current in said auxiliary circuit incident to the unbalancing of said primary coils for operating said detecting device.

2. A system of the character described comprising a pair of electric transmission lines, one of said lines being divided to form a pair of branches, a transformer including a pair of balanced primary coils arranged in the respective branches and a secondary coil, a pair of balanced choke coils arranged in the respective branches, a switch in one of said lines, an auxiliary circuit including said secondary coil, and means operative upon energization of said auxiliary circuit incident to the unbalancing of said primary coils for opening said switch.

3. A system of the character described comprising a pair of electric transmission lines, one of said lines being divided to form a pair of branches, a transformer including a pair of balanced primary coils arranged in the respective branches and a secondary coil, a pair of balanced choke coils arranged in the respective branches, a switch in one of said lines having a normal bias to open position, means normally holding said switch in closed position, an auxiliary circuit including said secondary coil, and means operative upon energization of said auxiliary circuit incident to the unbalancing of said primary coils for releasing said holding means.

4. A system of the character described comprising a pair of electric transmission lines, one of said lines being divided to form a pair of branches, a transformer including a pair of balanced primary coils arranged in the respective branches and a secondary coil, a pair of balanced choke coils arranged in the respective branches, a switch arranged in one of said lines and having a normal bias to open position, a thermostatic element normally latching said switch in closed position, a heating coil surrounding said thermostatic element, an auxiliary circuit including said secondary coil, and means operative upon energization of said auxiliary circuit incident to the unbalancing of said primary coils for energizing said heating coil to release said thermostatic element from said switch.

5. A system of the character described comprising a pair of electric transmission lines, one of said lines being divided to form a pair of branches, a transformer including a pair of balanced primary coils arranged in the respective branches adjacent one end thereof, a pair of balanced choke coils arranged in the respective branches adjacent the other end thereof, a meter connected in said last mentioned line beyond the last mentioned end of said branches, a resistance connected in said last mentioned line between said meter and the last mentioned end of said branches, said transformer further including a secondary coil, an auxiliary circuit including said secondary coil, a power theft detecting device, and means operative upon energization of said auxiliary circuit upon the unbalancing of said primary coils for operating said detecting device.

6. A system of the character described comprising a pair of electric transmission lines, one of said lines being divided to form a pair of branches, a transformer including a pair of balanced primary coils arranged in the respective branches adjacent one end thereof, a pair of balanced choke coils arranged in the respective branches adjacent the other end thereof, a meter connected in said last mentioned line beyond the last mentioned end of said branches, a resistance connected in said last mentioned line between said meter and the last mentioned end of said branches, said transformer further including a secondary coil, an auxiliary circuit including said secondary coil, a switch arranged in one of said lines, and means operative upon energization of said auxiliary circuit incident to the unbalancing of said primary coils for opening said switch.

7. A system of the character described comprising a pair of electric transmission lines, one of said lines being divided to form a pair of branches, a transformer including a pair of balanced primary coils arranged in the respective branches adjacent one end thereof, a pair of balanced choke coils arranged in the respective branches adjacent the other end thereof, a meter connected in said last mentioned line beyond the last mentioned end of said branches, a resistance connected in said last mentioned line between said meter and the last mentioned end of said branches, said transformer further including a secondary coil, an auxiliary circuit including said secondary coil, a switch arranged in one of said lines and having a normal bias to open position, means normally holding said switch in closed position, and means operative upon the generation of current in said auxiliary circuit incident to the unbalancing of said primary coil for releasing said holding means.

8. A system of the character described comprising a pair of electric transmission lines, one of said lines being divided to form a pair of branches, a transformer including a pair of balanced primary coils arranged in the respective branches adjacent one end thereof, a pair of balanced choke coils arranged in the respective branches adjacent the other end thereof, a meter connected in said last mentioned lines beyond the last mentioned end of said branches, a resistance connected in said last mentioned line between said meter and the last mentioned end of said branches, said transformer further including a secondary coil, an auxiliary circuit including said secondary coil, a switch arranged in one end of said lines, a relay having its coil arranged in said auxiliary circuit, an operating circuit including the armature of said relay, and means operative upon energization of said relay to close said operating circuit for opening said switch.

9. A system of the character described comprising a pair of electric transmission lines, one of said lines being divided to form a pair of branches, a transformer including a pair of balanced primary coils arranged in the respective branches adjacent one end thereof, a pair of balanced choke coils arranged in the respective branches adjacent the other end thereof, a meter connected in said last mentioned line beyond the last mentioned end of said branches, a resistance connected in said last mentioned line between said meter and the last mentioned end of said branches, said transformer further including a

secondary coil, an auxiliary circuit including said secondary coil, a switch arranged in one of said lines and having a normal bias to open position, a thermostatic element normally latching said switch in closed position, a relay having its coil connected in said auxiliary circuit, a heating coil surrounding said thermostatic element and an operating circuit including said heating coil and the armature of said relay and energizable to cause said thermostatic element to release said switch upon energization of said auxiliary circuit incident to the unbalancing of said primary coils.

10. A system of the character described comprising a pair of electric transmission lines, one of said lines being divided to form a pair of electrically balanced branches, means for causing the electrical unbalancing of said branches upon the connecting of either of said branches to the other line, an interrupter in one of said lines, and means operable upon the electrical unbalancing of said branches for operating said interrupter.

11. A system of the character described comprising a pair of electric transmission lines, one of said lines being divided to form a pair of electrically balanced branches, means for causing the electrical unbalancing of said branches upon the connecting of either of said branches to the other line, a switch in one of said lines having a normal bias to open position, means normally holding said switch in closed position, and means operable upon the electrical unbalancing of said branches for releasing said holding means.

12. A system of the character described comprising a pair of electric transmission lines, one of said lines being divided to form a pair of electrically balanced branches, means for causing the electrical unbalancing of said branches upon the connecting of either of said branches to the other line, a switch in one of said lines having a normal bias to open position, a thermostatic element normally holding said switch in closed position, a heating element surrounding said thermostatic element, and means operable upon the electrical unbalancing of said branches for energizing said heating element to cause said thermostatic element to release said switch.

13. A system of the character described comprising a pair of electric transmission lines, one of said lines being divided to form a pair of electrically balanced branches, means for causing the electrical unbalancing of said branches upon the connecting of either of said branches to the other line, a switch in one of said lines having a normal bias to open position, means for normally holding said switch in closed position, a normally open control circuit for said holding means, and means operable upon the electrical unbalancing of said branches for energizing said control circuit to release said holding means.

14. A system of the character described comprising a pair of electric transmission lines, one of said lines being divided to form a pair of branches, a transformer including a pair of balanced primary coils in the respective branches and a secondary coil, means for unbalancing said primary coils upon the connecting of either of said branches to the other line, an auxiliary circuit including said secondary coil, a power theft detecting device, and means operable upon energization of said auxiliary circuit upon the unbalancing of said primary coils for operating said detecting device.

15. A system of the character described comprising a pair of electric transmission lines, one one of said lines being divided to form a pair of branches, a transformer including a pair of balanced primary coils in the respective branches and a secondary coil, means for unbalancing said primary coils upon the connecting of either of said branches to the other line, an auxiliary circuit including said secondary coil, a switch in one of said lines, and means operable upon the generation of a current in said auxiliary circuit incident to the unbalancing of said primary coils for opening said switch.

16. A system of the character described comprising a pair of electrical transmission lines, one of said lines being divided to form a pair of branches, a transformer including a pair of balanced primary coils in the respective branches and a secondary coil, means for unbalancing said primary coils upon the connecting of either of said branches to the other line, an auxiliary circuit including said secondary coil, a switch arranged in one of said lines and having a normal bias to open position, means normally holding said switch in closed position, and means operable upon the generation of a current in said auxiliary circuit incident to the unbalancing of said primary coils for releasing said holding means.

17. A system of the character described comprising a pair of electric transmission lines, one of said lines being divided to form a pair of branches, a transformer including a pair of balanced primary coils in the respective branches and a secondary coil, means for unbalancing said primary coils upon the connecting of either of said branches to the other lines, an auxiliary circuit including said secondary coil, a switch arranged in one of said lines and having a normal bias to open position, a thermostatic element constituting a latch holding said switch in closed position, a heating coil surrounding said thermostatic element, and means operable upon the generation of a current in said auxiliary circuit incident to the unbalancing of said primary coils for energizing said heating coil to cause said thermostatic element to release said switch.

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